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Electrical Tests of the Efficiency of Worm Gearing.

For many years the standard text-books have taught and mechanics have believed that worm gearing is an undesirable method of transmitting power, its efficiency being believed to be low and the wear excessive. As regards gearing constructed on the old lines, there is no doubt that these ideas have been well founded, but nevertheless worm gearing has been put to an increasing number of uses of late years, and with very satisfactory general results. Worm-driven machine tools in which the work is not light are coming into increasing use, and especially worm-driven elevators have for some years been made which have operated with entire success. The late Robert Briggs was, we believe, the first to go boldly on record in the advocacy of worm gearing, saying: "Now, the fact is that the use of worm gearing for hoists, cranes, boring bars, lathes, etc., has been growing in favor, and it is found that neither excessive loss of power nor excessive wear of gearing ensues. In regard to friction, it is established that * * * well-fitted worm gearing will transmit motion backward through the worm, exhibiting a lower co-efficient of friction than is found in any other description of running machinery." The general line of change which has resulted in the improved results now obtained, has been in the use of steeper pitches than formerly, in the use of an oil cellar by which flooded lubrication is secured, and by the adoption of the Hindley form of worm.

While, however, the use of worm gearing has so largely increased and with such satisfactory general results, we are not aware that any figures have been published giving the actual efficiencies obtained, and we have great pleasure in presenting herewith diagrams showing the results of actual tests, and the efficiencies shown will, we doubt not, be a surprise to our readers, as they have been to ourselves. For these diagrams we are indebted to the courtesy of the Sprague Electric Elevator Company, who test all their elevators for efficiency with great thoroughness. The tests relate to their double-worm elevator, of which we showed illustrations in our issue for November 4th, and, it should be stated, are not exceptional, but represent a fair average of the results obtained. Different machines do not, of course, give identical results, some being slightly higher and others slightly lower, the machines selected for publication representing fair average results. By referring to the issue for November 4th, it will be seen that the machine under test was of the balanced double-worm construction, in which the work is divided between two worms, which, by means of connecting gearing, are balanced against end thrust, thereby obviating any thrust bearing with its consequent friction. The elevators are driven by an electric motor whose armature is located on a prolongation of the worm shaft. The power delivered to the machine, or input, is measured by volt and

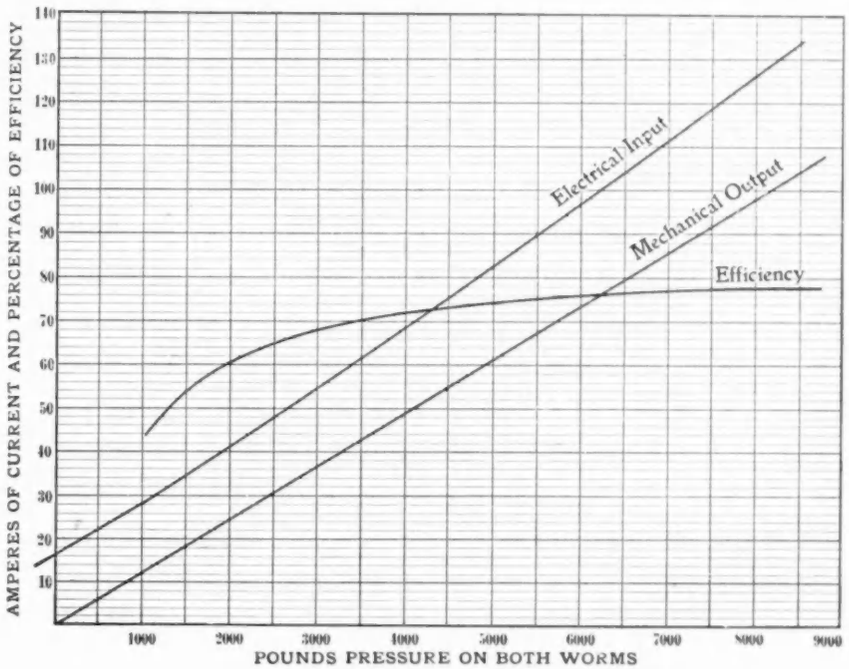

Fig. 1. EFFICIENCY OF HINDLEY WORMS

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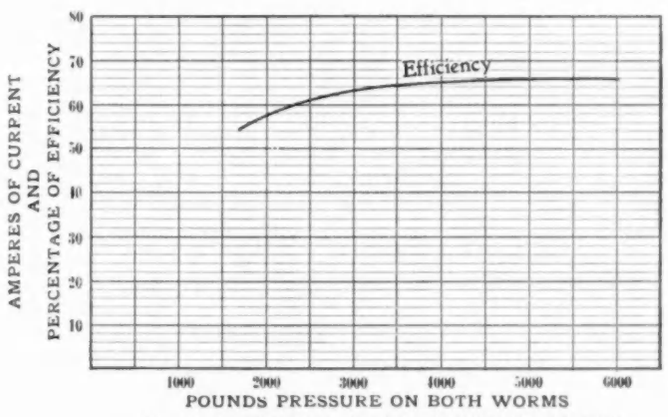

Fig. 2. EFFICIENCY OF COMMON WORMS

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ampere meters, while the output is measured by the actual lifting of weights which run in tall hoistways representing elevator shafts. These weights are arranged so that they can be lifted in any desired amount, and the whole arrangement forms an unusually complete and perfect equipment for carrying on such work. The input and output being measured in this way, it will be seen that the efficiency figures are really those for the entire elevator, the losses including the electrical and mechanical losses of the motor, as well as the losses due to the ropes and sheaves. It would, of course, be interesting, could these losses be determined and a figure obtained for the worm alone; but this is scarcely feasible. To begin with, the worm shaft bearings are also motor shaft bearings, and it is quite impossible to separate the mechanical losses of the motor and worms. The electrical losses of the motor are not, of course, a part of the worm losses; but it should be pointed out that the subtraction of the electrical losses would nevertheless be misleading, for the reason that the results found in this way could not be obtained by mechanical driving. A motor armature is driven by a self-contained force which produces no side pressure on the bearings; whereas, were the worm shaft driven by belt or gear, such side pressure would necessarily be present and give rise to fractional losses which are not present with motor driving. While, therefore, we should be glad could a curve be drawn which would ignore the electrical losses, we do not regard its absence as a source of serious regret; but it may be said in general terms that with these losses and those due to the rope and rope gear subtracted, the remaining efficiency of the Hindley worm, under the best conditions, can scarcely be less than ninety per cent.

The diagrams are from two elevators which are exact duplicates in every way, except that one of them was fitted with Hindley worms, while the other had worms of the usual type; and in addition to figures which give new information on this subject, the diagrams serve to show the degree of superiority of the Hindley worm.

The diagrams themselves are of an interesting form, which is due to Mr. Carrichoff, electrician of the Sprague Company, and deserve notice on their own account. The line of Fig. 1 for Hindley worms, which is lettered "mechanical output," represents the work actually done in hoisting the various weights translated into equivalent current. The mechanical power output is, of course, the product of the weight lifted and its speed, while the electrical power input is the product of the volts by the amperes. The speed and voltage are fixed, and hence may be ignored, or more properly speaking, canceled, and the weights lifted compared directly with the amperes supplied. In point of fact, as the pressure on the worm is a datum of more interest than the weight lifted, the figures at the bottom give the pressure on the worms produced by different weights in the elevator hoistway, the pressure on the worms being greater than the load on the rope, as the rope drum is of larger diameter than the worm wheels. Taking a specific case, a load producing a pressure of 2,000 pounds on the worms, as shown at the bottom of the diagram, when hoisted at the speed used, represents an amount of power equivalent to a current of 25 amperes of current supplied at the voltage employed, as shown on the vertical scale. In other words, were the machine without losses, or had it an efficiency of 100 per cent., 25 amperes of current would be consumed in lifting a load on the rope such as to produce a pressure of 2,000 pounds on the worms. In the same way the upper line, labeled "electrical input," gives the current actually used, as measured by the ampere meter when hoisting this load, which, we see, was 41 amperes. For this load it is obvious that $\frac{25}{41} = .61$ is the efficiency, and since the scale of amperes is of convenient magnitude, we may also use it for a percentage scale, and above 2,000 on the horizontal line lay down a point opposite 61 on the vertical scale, which has been done. In a similar way points have been located for each of the other loads, and the efficiency curve has been drawn through them.

Fig. 2, for the plain worm, gives the efficiency curve only, as it is the real objective point of interest, and its method of formation once explained, the other lines are no longer needed. It will be seen that the efficiency curve of the Hindley worm is materially higher than that of the common style.

In one respect these curves are misleading, and this should be pointed out. A material dropping-off of efficiency will be observed under light loads, which is largely due to the electrical drive, and under these light loads this method of testing is not as satisfactory as is desirable. The motor being designed for the heavier loads the electrical losses are relatively of more importance under a small load than under a heavy one, and this leads to a drop in the efficiency curve for small loads; but it will be understood that this loss is due, at least largely, to reduced electrical efficiency of the motor under less than its full load, rather than reduced mechanical efficiency of the worms.

Following are the particulars of the worms under test:

Velocity ratio—29½ to 1.

Pitch diameter of gear—26.89 inches.

Pitch diameter of worm—5.47 inches.

Double-thread worm.

Lead of each thread—2.86 inches nearly.

Angle of thread at pitch line—9° 39′.

Speed of worm—500 revolutions per minute.

Rubbing speed at pitch line—718 feet per minute.

Lineal speed of travel at pitch line of worm wheel—112 feet per minute.

The figures on the base line give the total pressure on the two worms. The pressure on each worm is, of course, one-half the figures given.

These tests are an illustration of the fact, which we have pointed out before in connection with the power tests of machine tools, that the electrical system of driving affords unusual opportunities for acquiring valuable information, and may be expected to add appreciably to the store of mechanical knowledge.

We expect in the near future to publish, from the same source, the particulars of further tests on worms of different pitches, by which the effect of variations in the pitch will be disclosed, and also on single worms with thrust bearings. In this connection we may also say that we shall soon publish an illustrated account of the shop methods of constructing Hindley worms. This pattern of worm was invented more than a century ago (having been described by Smeaton); but until recently it has been but little more than a scheme, as but few of them were actually used. In point of fact, their construction is a very different matter from what would be expected from the idea of the worm, and difficulties are involved which have required hard thinking to surmount.

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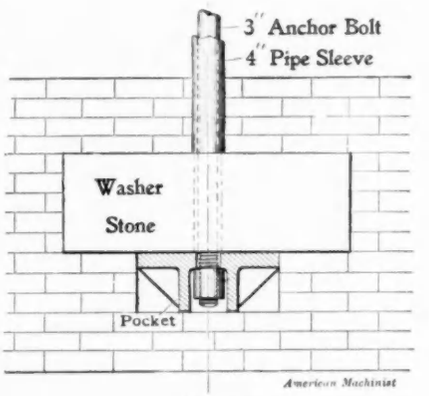

Fig. 1

Repairing an Anchor Bolt.

BY CHARLES A. HAGUE.

Anchor bolts are no doubt looked upon by engine builders as more or less of a nuisance, and the chances taken in this direction in burying one end of them deep down in a mass of masonry, hoping that no harm will come to them, are very numerous. Well, perhaps the percentage of anchor bolts getting into trouble is small, but nevertheless whoever happens to have one break, and has no pocket arranged in the foundation to facilitate the removal of the lower nut, finds considerable annoyance and expense in remedying the difficulty. When we come to contemplate the study and care expended upon the various

parts of the engine to facilitate overhauling, inspection, etc., it does seem just a trifle reckless to shut off all communication with the business end of the anchor bolt; but then engine builders are apt to think that the anchor bolts belong to the foundations, and as long as a good engine is furnished the buyer ought to see that there is a good place to put it, and provide something adequate to hold it there; at any rate there are plenty of anchor bolts in use that look as though they had been put in with with the idea of reaching their lower ends by means of an earthquake or a dynamite bomb.

The engine man must not be held too rigidly to account, however, for there is a commercial side to the case, and that queer element called "competition" can change from the "life of business" to the death of a steam engine, just about as readily as a "bull" can change to a "bear." There have been many cases wherein the additional value of a proper foundation as against a criminal apology for one, have brought disaster and expense to the buyer who only understood the difference in the cost, and who took a bad thing at a low price upon the face of it, as against a good thing at what was really a much better bargain at a little higher figure.

The anchor or holding-down bolt, referred to in the caption of this article, belonged to a large mill engine, and had broken square off about 40 inches below the upper nut; the bolt was 3 inches in diameter and 9 feet long, and the distress to the engine arising from the fracture was perfectly evident. Therefore, although a few days might not bring serious results, it was plain that any great delay in making repairs would certainly produce abnormal and dangerous effects. In this particular case the lower nut was held by a cast-iron plate designed to secure the nut in a normal position even if the bolt should be removed; or more concisely, the plate containing the lower nut could be located and set accurately, and also partly built in before the bolt need be screwed into place, thus insuring the absolutely correct position and bearing of the anchor bolt nut without that trouble or inconvenience which sometimes induces a careless mason to do very bad work to save himself trouble. The way to do it is to so design the foundation that it will be harder for the masons to make it wrong than to make it right, and this will be found to be the very essence of engineering; an example of this sort of practice is found in the sharp points attached to iron railings in public places to keep loungers from sitting down; all the instructions in the universe would not suffice to keep the loungers off the railings, but the sharp points represent persuasive eloquence in its highest form.

The fact that the bolt broke off more than 3 feet below the top nut, the broken end being located somewhere below the cap-stone down within the 4-inch pipe, of course rendered futile all efforts to get a hold upon the bolt so as to unscrew it from the bottom nut, it being known from the foundation plans that the lower nut was safely held in place and would certainly remain so after the bolt was unscrewed and removed. The plan hit upon and successfully carried out (see sketch) was to drill with a ratchet drill a 1-inch tapping hole, vertically of course, into the broken end of the anchor bolt remaining in the foundation; then tap this hole with a left-hand tap, made for the purpose and provided with the guiding collar, as shown, the bolt having first been caught and held in place by means of the piece of sharpened tube (see Fig. 2). The anchor bolt was found to be sufficiently seized in the lower nut to resist the work of tapping, but when an eye-bolt, made to suit the left-hand tap, was screwed hard down, the bolt commenced to turn to the left, and was soon out of the lower nut; a tackle hooked into the eye shortly had the lower part of the broken bolt out upon the floor.

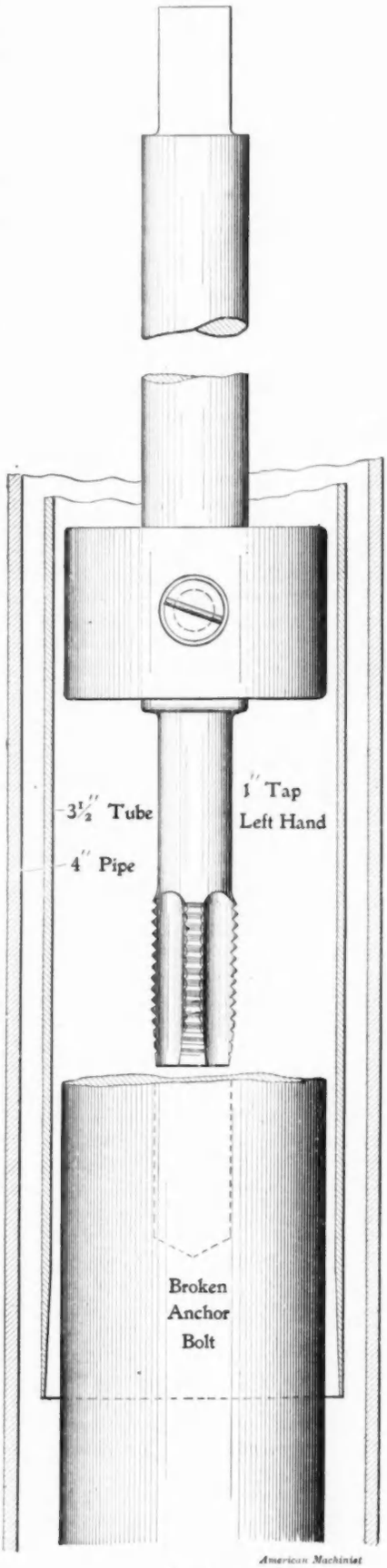

Fig. 2

REPAIRING AN ANCHOR BOLT.

The original length was restored by welding out; then a right-hand thread was cut to match the top nut; then, after drilling and tapping a three-quarter hole with a right-hand thread and providing an eye-bolt to match, the repaired anchor bolt was lowered and screwed into place in the lower nut, the top nut was put on and set down hard, and the trouble was past. Before attempting to return the bolt to its place, the lower end was slightly pointed, so as to insure ease of catching the lower nut, and the threads were carefully cleaned and smeared with grease.

There are no doubt many cases where the good fortune of having the lower nut so completely held in place would not be met with, and this brings forcibly to mind the importance of having some sort of provision for meeting troubles of this nature. Of course, tunnels and pockets can be built in the masonry to afford access to the lower ends of the bolts, but, as already pointed out, the engine men are getting too sharp commercially to handicap their figures by offering such luxuries as properly planned foundations.

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Another compressed-air wonder-worker is reported in the daily papers; this time it is in Portland, Me. "The air pump furnishes just three times more air than is necessary to run the auxiliary compressed-air engine, and thus the machine is constantly laying up power with which to run." It is said that only $5,000 has been expended upon it up to date, but a stock company is soon to be organized, and it is to be boomed in the usual way.

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It is announced that Mr. Frank E. Barnard has been made a member of the firm of B. M. Jones & Co., the steel merchants, of Boston, Mass.

The Error of Comparative Tests.

BY W. H. BOOTH.

I have frequently observed that when some new appliance is brought forward, the attention of the public, or of the purse of the public, is drawn to the appliance by the publication of a comparative test which shows that a certain steam plant, for example, worked in the ordinary manner, will produce a given result, whereas, if worked with the addition of some patent appliance, be it a novel feed heater or a furnace bar, very much better results are obtained. In most cases the figures put forward have probably been actually obtained, and no untruths have been stated; and yet the conclusions drawn are by no means correct. I have a few cases in my mind, or in my notebook, as I write. One example which I very well remember was that of a furnace for which economies of 50 per cent. were claimed, and the promoters of the affair published a certificate from a responsible firm who were using the patent, which told how this saving actually had been obtained. It was not for some months that I was able to find out the truth in the matter; but one day I was able to see the boiler and the furnace at work. I then discovered that the work of the boiler was exceedingly light, and the weight of fuel burned was ridiculously small, and firing was a very haphazard matter indeed. Hitherto the firm had been using the most expensive coal, for no good reason. The wily patentee got leave to put in his furnace, and guaranteed to save so much. He at once used the very cheapest coal, small stuff at less than half the price of the hitherto employed "best Welsh," and naturally he made an economy of 50 per cent., just as he could have done had he made no change in the boiler and simply advised a change of fuel. This shows the value of a certificate of economy where not accompanied by fuel data as to the size, power and fuel consumption before and after alteration. When I saw the boiler, it was doing its ordinary duty and had little more fire in it than I have seen in an ordinary kitchen grate.

Comparative tests are often published in which the comparison is much emphasized, and no figures given which bear on actual performance. Perhaps if such figures were forthcoming, it would be seen that the best figures obtained are much below the ordinary run of work. A case I remember well had to do with an appliance which was stated capable of giving great economy. The test was a comparative one, and the results were so enormously in favor of the new appliance that in running out the figures we could neglect great items and yet find economies of hundreds per cent., altogether out of reason or possibility. A little consideration will show us that such things are possible.

Let us suppose that a given engine has its steam from a boiler that is much too small for it, and that it is not possible to run the engine with more than five of the ten machines which it ought to drive. The feed is cold and the coal is bituminous, and the firing frequent with an insufficient grate area. Someone who knows the conditions comes along with a feed-water heater and states that with it he will cause that engine to drive its full load and with less fuel. Of course, this looks very tempting to the owner, who wants to run all ten machines. At the same time, he may be perfectly aware that between feed water at 40 degrees and 212 degrees he cannot expect more than 18 per cent., or thereabouts. However, he gets the heater put in. The immediate result is that when feed is turned into the boiler, the pressure does not drop as it hitherto has done. Therefore the cut-off valve does not proceed to admit steam for a greater percentage of the stroke. At once, then, we see that the engine does not become more wasteful. Hitherto, as soon as the feed has been turned on, the engine has gone into later cut-off simply because of the drop in the pressure, and, once the engine has begun to eat more steam, the difficulty of getting up pressure again has been greatly increased. The want of steam has stimulated the fireman, who has piled on coal and has only succeeded in giving a thick coat of badly heat-conducting soot to the whole of the heating surface of the boiler, and in making a fire with a dull, black surface. On putting in hot feed and reducing the demand for steam, there is given time for the fire to burn bright. The soot and tar are burned off the plates and tubes, and increased steam production at once takes place. The firing can then be moderate, and the good condition of the furnace remains permanent. Thus, simply because the boiler was a trifle too small for its duty, it failed to drive half its load. As soon as it was relieved of 18 per cent. of its duty, it began to clear itself of dirt, to raise its pressure to a more economical point, and very soon was able to drive a much bigger load and consume less coal in doing so. But higher pressure means less water per horse-power, and actually less hot feed than cold is called for, and down goes the coal consumption. Such very marked differences as this are not always to be met with, but I have seen them in small plants where the boiler has happened to be too small for its duty by a small percentage, and where an appliance giving an economy of only a few per cent. has brought the boiler to a condition of efficiency.

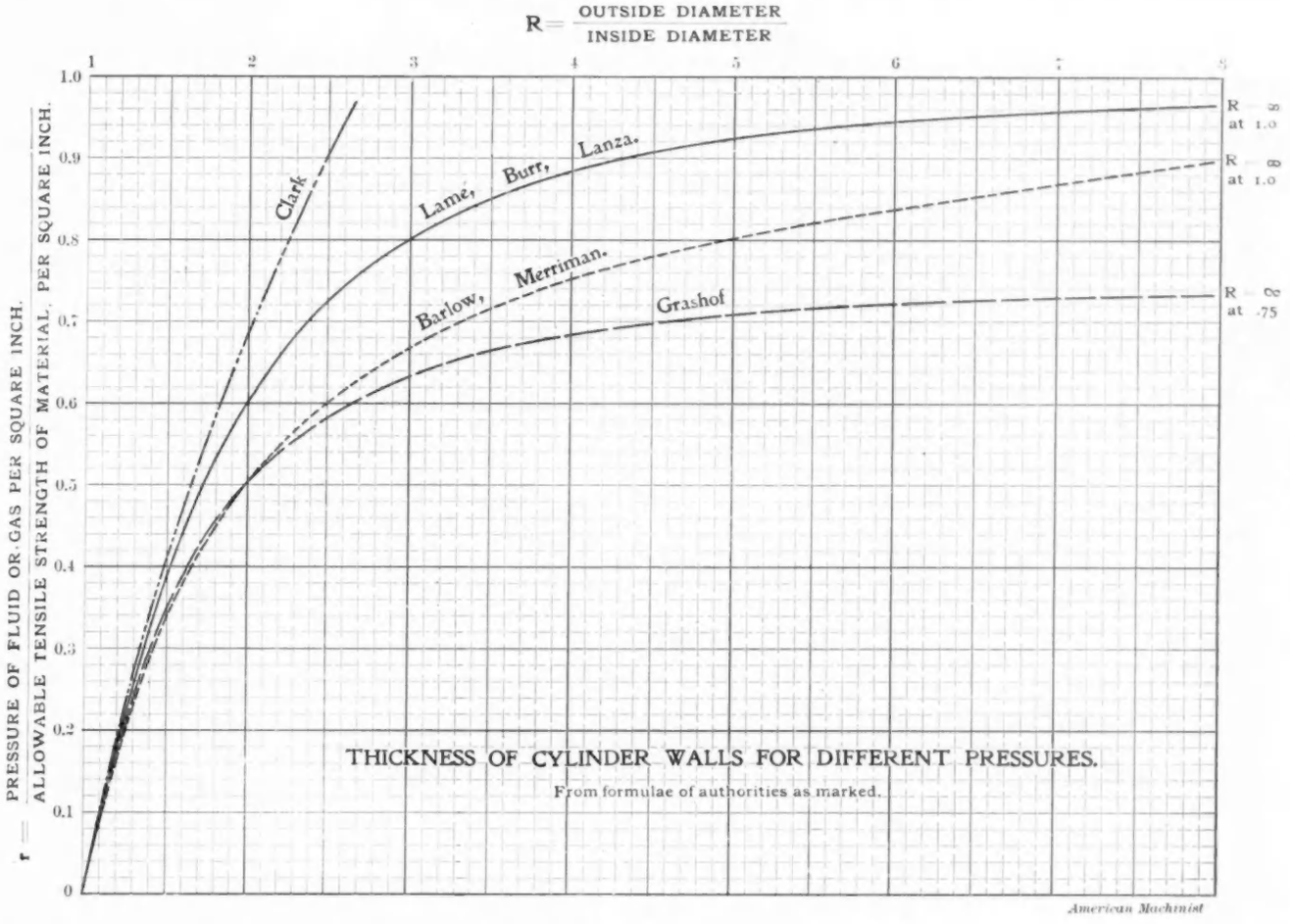
If my reasoning is correct, it is then perfectly obvious that engineers should be on their guard against all reasoning based on comparisons. In tests of the sort I have indicated, as for example of a feed heater, nothing approaching a true result can be obtained, unless without the feed heater the engine could be worked at the same pressure as with it. Any fall in pressure would obviously alter all the conditions so as to entirely vitiate the results obtained. It has occurred to me that where comparative tests show such enormous variations in fuel efficiency as they sometimes will do, there should be some means of ascertaining just how much really is due to the innovation. When the addition of some fresh appliance makes an enormous difference in fuel consumption, it must have some power for good. It has clearly lifted the boiler across what we may term its critical point. Below such point the outgoings exceed the income; above the critical line the outgoing is less than the income, and the accumulations of income rapidly augments. It is like two men who have an equal income; one over-spends a cent per day, the other saves a cent. In time the difference is noticeable.

Just what rule should be followed to estimate, from a comparative test, the actual value of an appliance producing results of undue magnitude, I cannot say, but it has occurred to me that the fourth root of the efficiency ratio would not be far out. Thus it is found that one pound of coal is productive of a double brake power by the use of a feed heater—what is really due to the heater. The fourth root of 2 is 1.18. Therefore the economy is 18 per cent. From this we should argue that, if the boiler had been originally 18 per cent. greater, it would have kept up steam pressure and economical working, and the addition of a heater would simply have saved fuel to the extent only of 18 per cent.—the true figure under the circumstances. But as the boiler was too small, to begin with, the lack of the heater caused a cumulative loss up to 100 per cent. I have known a change which was only claimed to give an economy of 30 per cent., to show nearer a six-fold efficiency ratio. Now, the fourth root of 6 is 1½, which is a more likely figure than 6. I do not tie myself to the fourth root, but merely suggest the idea. It may be that the radix figure is the ratio itself, and that a six-fold improvement should be taken to represent an actual economy of $\sqrt[6]{6}$, or 1.34; or the actual process may be, and probably is, much more complex than can be given by a simple root. Certain it is, that abnormal gains on a previously insufficient plant must not be taken as any index of the proper value of the appliance which produces or causes such gains. Comparative tests thus obtained are entirely worthless, except to show that there is some advantage which, in a particular instance, has happened to act in a cumulative manner. There are such frequent instances of these peculiar comparisons, that one is induced to believe that a steam plant is specially designed to be just below the critical line so that it may be raised above the

line of a few per cent. of increased efficiency.

I have laid stress on these points because so many instances have come under my notice of abnormal economies or efficiencies arising from totally inadequate causes. The claims made for abnormal economics arising from the use of a certain appliance may be true enough for a particular instance, but may be so extravagant as to lead people to set down the whole thing as a fraud; whereas, properly looked at, there is nothing more than can be explained by a perfectly legitimate and small saving. The addition of 15 per cent. to a boiler which is only just a trifle too small, will make it an easy boiler to work. If we once realize the principle of cumulation, many things will appear plain that are now shrouded in mystery.

London, Eng.



Thickness of Cylinder Walls for Different Pressures.

BY W. T. SEARS.

The question of dimensions for cylinders of cast iron or steel, subject to internal pressures of from one to four thousand pounds per square inch, is one of considerable moment, and the writer, for the sake of reference and curiosity, once plotted the curves shown in the accompanying chart from formulæ of the different authorities as noted.

The figures at the side represent the ratio between the pressure per square inch to which the cylinder is subjected and the allowed fiber strain of the material employed.

The figures at the top represent the ratio between the outside diameter and the inside diameter, or what is the same thing, between the outside radius and the inside radius.

The curves are rather interesting. Take, for instance, the formula of Grashof (from Unwin's "Machine Design"), which shows that the cylinder walls must be infinitely thick when the pressure is three-quarters of strength of material used, and compare it with Clark's, which shows under like conditions that the outside diameter is a trifle more than two and one-tenth times the inside diameter.

Reuleaux states that the formula of Lamé is probably the most correct. Kent, in his "Note Book," gives the formula of Merriman.

From the point where the pressure gets to half the allowed strength of the material, there is a great and increasing difference.

Up to three or four thousand pounds pressure per square inch, taking cast iron at about six thousand, the formula of Lamé seems to have given good results in practice. Of course, the ends of short cylinders increase the strength to a considerable extent; but it is usually disregarded. I think. I have no data for higher pressures than those quoted, but should be pleased to hear from any of your readers who possess such.

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Fine Work in Washing Up.

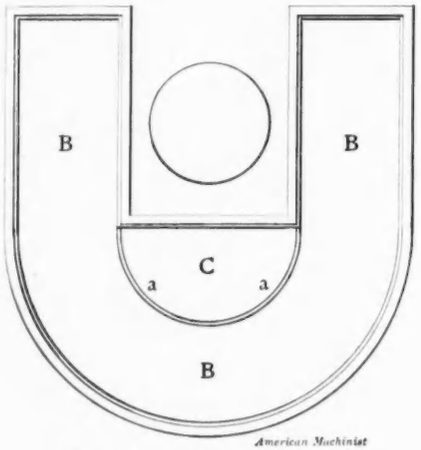
We probably never had more indubitable evidence that the trade of the machinist is advancing than has come to us in the past few days. In the shops we are certainly getting down to finer work than has been customary heretofore. No fine work, as everyone knows, can be done with a single cut. As a rule, no metallic surface can be produced with proper truth and finish, without taking first a roughing cut and then a finishing cut. The same rule applies to the finishing of the machinist's face and hands, and we are glad to note that this is coming to be recognized. In the shops of P. Pryibil, in New York, we recently noticed a wash trough designed to carry out the idea. This trough was cast to go around a post in a convenient place in the shop, and the general shape of it is one that would be evidently convenient in many cases; but what particularly attracted our attention was the provision made for the fine work.

A is the pillar and *B B* is the main trough. *C*, however, is a part of the same trough, separated by the partition *a a* from

the rest of it. The trough is of the usual depth, and the partition *a a* is not as high as the sides by an inch or so. There are holes communicating between *B* and *C* in the bottom of the partition *a a*, so that when the water is let into *C* it runs also into *B*. The trough is provided with the usual overflow and means of employing it when required.

The intention of the arrangement is that *B* shall be used for the rough work and *C* for the fine work, or that the heaviest dirt shall be washed off first in *B* and a final rinse or polish taken in *C*. That the trough was actually used as intended was evident when we saw it, from the fact that the water in *C* was decidedly cleaner than in *B*.

Inventions run in a peculiar way, and it often happens that a happy idea developed in one locality needs still another happy idea developed elsewhere to make the thing complete, and this is true in the present case, and we are glad to be able to bring together the two special features of the same line of invention and development. At the Gould & Eberhardt shop,



FINE WORK IN WASHING UP.

Newark, N. J., they hang up two towels, side by side, and a sign above one of them says "Hands," and that above the other says "Face." Anyone can catch the idea and readily see how the double towel arrangement belongs to the double trough, or vice versa.

These things surely indicate progress. The washing-up of the machinist when the whistle blows has usually been characterized by speed rather than by care and precision; but this is evidently changing, as the means above indicated show. In one of the recent letters on the apprentice question, one employer stated that every apprentice was required to wash before leaving the shop, and we may possibly hear before long that he is required to take two cuts.

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Mr. Curtis W. Shields, lately with The Ingersoll-Sergeant Drill Company, now represents the Pedricks & Ayer Co., of Philadelphia, at 111 Liberty street, New York.

Experimental Investigation of the Cutting of Bevel Gears with Rotary Cutters.*

BY FORREST R. JONES AND ARTHUR L. GODDARD.

The usual method in shops which do not make a business of cutting bevel gears is either to run several trial cuts and test the gears until they mesh satisfactorily, or to file the teeth. While such "cut and try" methods may produce teeth whose outlines are more nearly the correct form for bevel-gear teeth than those of teeth formed with two cuts, very frequently they do not, and the extra time required for such operations is generally time wasted.

The operations in detail required to cut bevel gears with rotary cutters in a milling or similar machine are as follows:

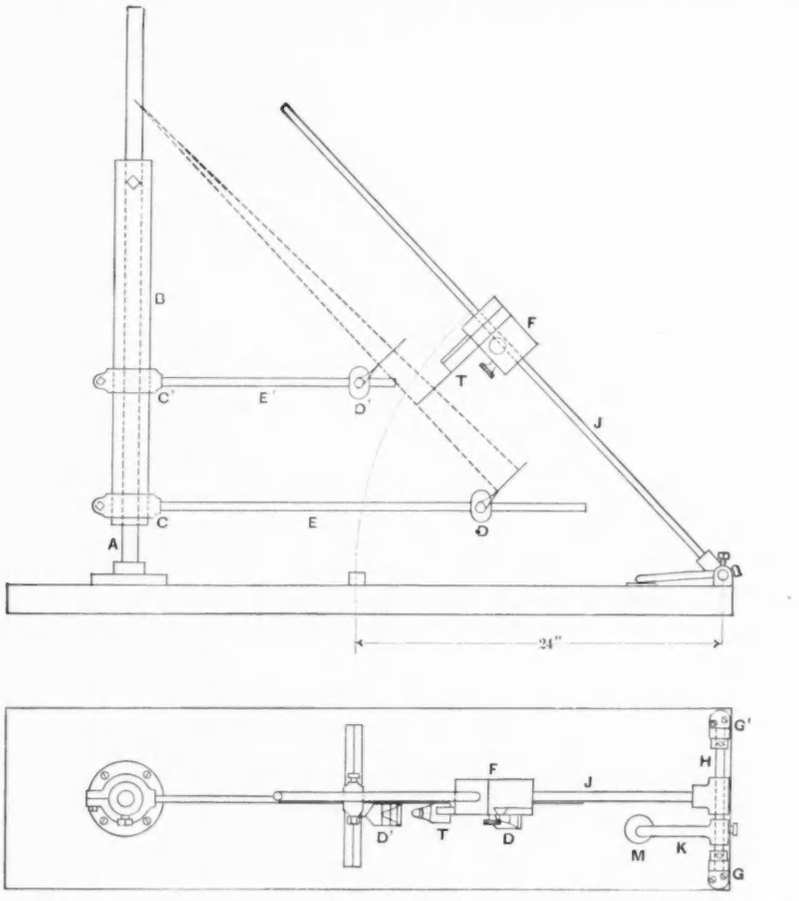

Fig. 1. SKETCH OF MACHINE FOR DETERMINING ANGULAR MOVEMENT OF GEAR BLANK.

After the gear blank is set so that its axis lies in the median plane of the cutter and at the proper angle of elevation, cuts are run through it to rough out two or more of the spaces between the teeth; the middle of the tooth and its thickness are then marked on the pitch circle of the large end; the gear blank is then revolved through a small angle, less than that of a single pitch, and the table moved sidewise until the side of the cutter passes through one of the pitch points marking one side of the large end of the tooth, and a cut is taken on one side of all the teeth. The blank is then revolved an equal amount on the opposite side of its original position, and the table shifted to correspond, after which a cut is taken on the unfinished sides of the teeth, thus completing the gear.

The only uncertainty in these operations is that of revolving the blank from its original or central position through such an angle that the cutter shall pass through the pitch point of the larger end of a tooth, and at the same time cut just enough off the smaller end to allow the gear to mesh with its mates without further dressing of the teeth.

A study of the problem led to the supposition that the amount a gear must be thus revolved could be expressed in terms of the pitch, the co-efficient being a variable depending upon the center angle of the gear, which is here taken as the angle between an element of the pitch cone and the axis of the gear. It was also thought that this angle through which the gear must be revolved must be independent of the pitch of the gear; for, with a given pitch cone to be provided with a certain number of teeth, any pitch may be given to the resulting gear by selecting the base of the pitch cone at the proper distance

*A paper presented at the New York meeting (December, 1896) of the American Society of Mechanical Engineers.

from its apex to give the gear the required pitch diameter, since the pitch diameter of a bevel gear is measured on the larger end of the gear. And it is obvious that the setting which will answer for cutting a gear taken from one part of this cone will answer for cutting a gear taken from any other part; yet the two gears would be of different pitches.

In order to determine the proper setting for gears of different center angles, the following apparatus was constructed and used experimentally.

In Fig. 1 the vertical rod A serves as the axis of a gear; the sleeve B may be revolved upon and moved up and down A, and clamped in any desired position by means of the set screw shown; the split collars C and C' may be turned or moved to any desired position upon B; these collars carry smooth rods E and E', on

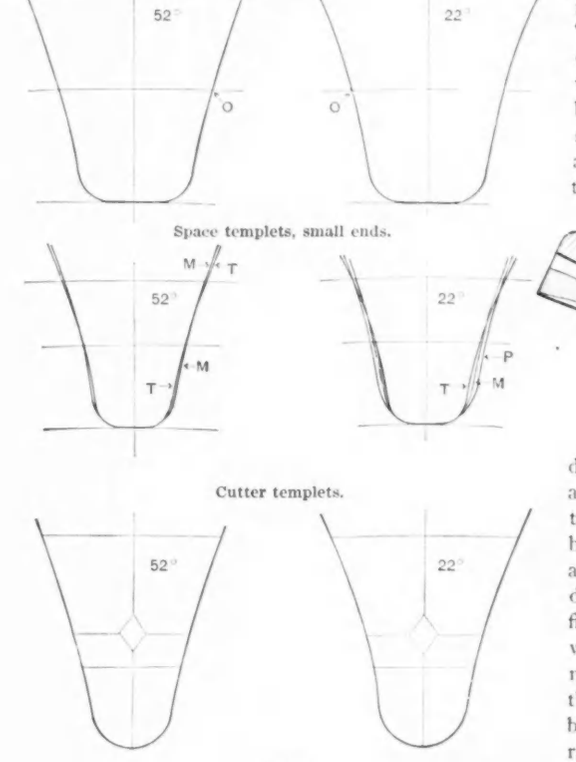

Fig. 1.

which the brackets D and D' may be moved and clamped wherever wanted; upon D and D' are clamped the outlines of the outer and inner ends of the space between two teeth of an involute bevel gear. The outline of a segment of a beveled gear of any desired center angle or pitch may thus be constructed. T is the outline of a cutter templet drawn upon stiff cardboard; it is clamped to the bracket F, free to slide along the rod J, which is splined to receive a key attached to F; F is rigidly fastened to the horizontal shaft H, which is free to turn in its bearings G and G'; J may be fixed at any desired angle by clamping upon H the dog K, one end of which swings down against a flat plate M; the shaft H may be moved endwise in its bearings, which movement corresponds to the lateral motion of the table of a milling

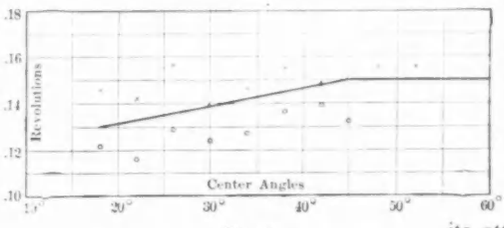

Fig. 3.

machine, except that in this case the work is stationary and the cutter is shifted.

The operation of the machine was as follows: The outlines of the outer and inner ends of a tooth space of a bevel gear of one inch pitch and fifty teeth, were drawn by the approximate method as given in Brown & Sharpe's "Treatise on Gearing." The outline of a cutter templet was drawn upon stiff cardboard, the curve being the same as that of the space at the large ends of the teeth. Pitch circles and me-

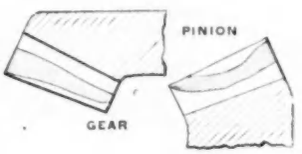

Fig. 4.

dium lines were drawn upon all the cards. Fig. 2 shows two sets of templets for bevel gears having center angles of 22 degrees and 52 degrees respectively, and fifty teeth each. The rod J was set parallel to an element of the pitch cone of the gear. This was done by calculating, for a 24-inch radius, the chord of the complement of the center angle, and measuring the length of chord thus determined with a steel tape from points on J and on the base 24 inches from the axis at G, as shown. Then the plates at D and D' were set perpendicular to J, and the space templets clamped on. The positions of these templets were determined by measuring the radii of the pitch circles from A, and making the distance between the two templets one-third the slant height of the pitch cone. The two templets were brought into alignment by sighting across two threads, one stretched along the base of the machine, and the other stretched from the top of A to the top of J, care being taken first to see that J was in proper alignment with A. The cutter templet was then clamped to the slide F, and the inclination of J was changed to that of the cutting angle. This was determined by adjusting until the lower edge of the cutter templet would pass through the circles marking the bottom of the space at both ends of the tooth. A hole cut in the middle of the cutter templet, as shown in Fig. 2, allowed the coincidence of the median lines to be determined. This completed the operation of setting up the machine. Next the sleeve B with its attachments was revolved through a small angle, and the shaft H was slid along in its bearings until the edge of the cutter templet passed through the pitch point marked O in Fig. 2. The slide F was then moved along until T rested upon the inner space templet. The rod J was swung up to allow moving the slide past D', and as the dog K came down upon the flat plate the rod would come back to its original position when lowered. The amount of revolution was ascertained by marking through the hole in the cutter templet upon the pitch line of the outer card and measuring the distance of this mark from the median line drawn on this card. This was then reduced to decimals of a pitch.

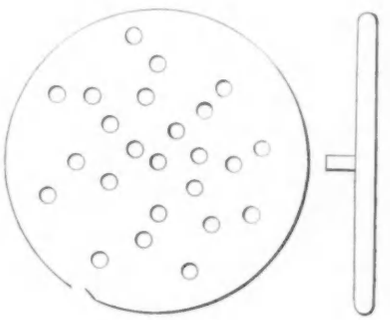

Fig. 5.

It was at first considered necessary to revolve the gear enough to have the edge of the cutter templet pass through the outer pitch point O and the corner of the top of the inner end of the tooth; but, as may be seen from Fig. 2, curve P, on gears of small center angle this cut the root of the tooth away considerably. It was then considered advisable to revolve the gear so that the cutter left nearly as much at the top of the tooth at the inner end as it took off at the root. The settings which would produce this result were determined for a number of gears of center angles varying, by steps of 4 degrees, from 18 degrees to 52 degrees. At the same time the settings which would cause the edge of the cutter to pass through the outer pitch point O and the corner of the top of the inner end of the tooth were determined. The former series of settings, indicated by X in Fig. 3, seemed to require a revolving of the gear through about .15 of a pitch for any center angle of 18 degrees and upwards; and the latter series,

indicated by ©, seemed to require a revolving through about .13 of a pitch. But it was noticed that as the center angle increased, less stock was left on the top of the tooth at the inner end, and less was taken off at the root. This is shown in Fig. 2; on the space templet for the small end of the space for the gear of 22 degrees center angle, the line marked *T* indicates the true outline of the space; the line marked *M* indicates the outline of the space as it would be when cut if the gear were set so that the cutter left as much stock on the inner end of the tooth at the top as it took off at the root; and the line marked *P* indicates the outline of the tooth as it would be when cut if the gear were set so that the edge of the cutter would pass through the corner of the tooth at the top of the inner end. On the templet for the inner end of the space for a gear of 52 degrees center angle, the lines marked *T* and *M* indicate corresponding features of the tooth; but here the lines almost coincide. This shows how much more nearly correct gears of large center angles are when cut with rotary cutters than those of small center angles. This is because the circles upon which the teeth are developed grow greater in proportion to the pitch circles of the gears as the center angle increases; hence the involute outlines of the teeth approximate more closely to a straight line, and there is consequently less difference of curvature between the two ends of the teeth.

The greater variation from the correct outline in the gears of small center angles, as shown by the curves *T* and *M* in Fig. 2, would be still more marked were it not for the fact that when a gear of small center angle rotates through any given angle, a point on its pitch circle (at either end of the teeth) passes through a greater portion of the circle upon which the teeth are developed than it does for a large center angle; therefore, for a given amount of rotation about its axis, a tooth of a small center-angled gear has a greater angular rotation about its centers of development than one of a large center angle. (The center of development is taken as the intersection of the axis of the gear with a line normal to the surface of the pitch cone at the same distance from its apex as the section of the tooth under consideration.) This greater rotation about the center of development causes more metal to be removed from near the top of the tooth of the gear having a small center angle.

The difference of effect upon the inner ends of the teeth would prevent the extra thick points of the teeth of small center angles from entering the spaces of gears of larger center angles with which they are to run. It was deemed best to cut the gears of larger center angles as nearly correct as possible, and to cut the gears of smaller center angles to mesh with them. A curve was drawn, therefore, between the two series of settings which had been determined, which, it was thought, would give this result. This curve is shown by the heavy line in Fig. 3. Then four pairs of gears were cut with Brown & Sharpe's involute bevel-gear cutters, according to the settings indicated by this curve. The gears were: 6-pitch, 20 and 30 teeth, center angles 33⅓ degrees and 56⅓ degrees; 7-pitch, 16 and 36 teeth, center angles 23¼ degrees and 66¾ degrees; 7-pitch, 28 and 48 teeth, center angles 30¼ degrees and 59¾ degrees; and 10-pitch, 32 teeth, center angles 45 degrees. The settings were:

Center angle	23¼	degs.	revolved	.135	cir.	pitch.
"	"	30¾	"	"	.139	"	"
"	"	33⅓	"	"	.141	"	"
"	"	45	"	"	.150	"	"
"	"	56⅓	"	"	.150	"	"
"	"	59¾	"	"	.150	"	"
"	"	66¾	"	"	.150	"	"

These gears all meshed to the correct depth and ran with the bearing surface extended the whole length of the tooth. At a speed of about 400 feet per minute at the periphery, the gears with the greatest velocity ratio rattled considerably; but this must always be the case with such gears cut with two cuts, if the bearing is to be distributed along the whole length of the teeth. If it is more desirable to have the gears run quietly than to bear the whole length of the teeth, then they should be revolved less from the central position, thus allowing more to be cut from the inner ends of the teeth, which would leave the bearing almost altogether at the outer ends.

The 7-pitch gears of 16 and 36 teeth and the 6-pitch gears of 20 and 30 teeth had faces ¾ inch long, which is about one-quarter of the slant hight of the pitch cone, as those were the dimensions for which the cutters were designed. The shaded parts of Fig. 4 show how the bearing surfaces were distributed along the sides of the teeth of these gears. The 7-pitch gears of 28 and 48 teeth had a length of faces also about one-quarter of the slant hight of the pitch cone; but in this case the faces of the teeth were 1¼ inches long. The bearing surfaces of the teeth of these gears were distributed similarly to those shown in Fig. 4. The 10-pitch miter gears of 32 teeth had faces 1 inch long, which is about .44 of the slant hight of the pitch cone. The bearing surfaces of these gears were distributed similarly to that shown for the pinion in Fig. 4.

The exact setting desired cannot usually be obtained on the ordinary dividing head of a milling machine, so the spacing device shown in Fig. 5 was made. It is a circular plate ⅛ of an inch thick, with a pin in the center which fits in the holes of the index plate of the dividing head of the gear-cutting machine, and has a series of holes of the size of those in the index plate, arranged in a spiral. The required partial revolution of the gear to obtain the correct setting is reduced to decimals of a revolution of the index plate. Suppose this requires .125 of a revolution of the index plate, as was the case with the gear of 48 teeth. The index plate used had 20 holes in the outer row, which makes two and one-half of its spaces correspond to the required .125 revolution. Therefore the pin on the spacing plate was inserted in the hole in the index plate second from the one in which the locking pin of the dividing head had been inserted, and then the index plate was turned till the locking pin entered the proper hole in the spacing plate, which, of course, in this case, was at a distance from the center pin of the spacing plate equal to one-half of the space between consecutive holes of the 20-hole row of the index plate.

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Compressed-Air Refrigeration.

BY FRANK RICHARDS.

I have lately received a personal letter in which the following occurs:

"The paper written by you which appeared in the October 1st issue of the 'American Machinist,' upon 'Domestic Refrigeration,' was especially interesting to me, and in speaking of the use of air for this purpose to a friend he was struck with the possibilities in this direction, and in his desire to get some more information on the subject he went to see one of the best chemsts here, who told him that while it appeared to produce cold in theory it would not in practice. The chemist was referred to your articles, but he thinks you are an enthusiast. Now I would like to know if the degree of cold you mention has ever been produced by experiment, so that I can convince my friend that the articles which appear in the 'American Machinist' are based on facts and not on theories."

I have to say that my statements regarding the fall of temperature accompanying the re-expansion of air are based upon theory, but the theory is based on fact. There is too much actual refrigeration by the use of compressed air constantly going on to allow of any dispute as to its possibility. Compressed-air refrigeration is employed upon many warships, and is also used exclusively upon vessels carrying dressed meats and other perishable goods for the longest ocean voyages.

An interesting plant employing compressed air for refrigeration came under my observation only last year, and a reference to it may perhaps enable us to perceive what seems to be an essential feature of practical refrigeration. In the case referred to it was considered necessary to freeze a considerable section of earth or sand so that it would be retained in place during the progress of an important engineering undertaking. Several pipes, say 6 inches in diameter, were driven down into the earth where the refrigeration was required, and arrangements were made for circulating through them a constant current of air at a temperature consider-

ably below the freezing point. The low temperature was actually secured by the re-expansion of compressed air, and this low temperature was maintained for a period of, I think, two or three months.

The main compressor used was of the usual straight-line type, with a steam cylinder and an air-compressing cylinder in the same straight line, and with their pistons moving together; but in connection with the steam cylinder, and also in the same straight line, and forming also a part of the driving apparatus, was another cylinder operated by the compressed air. The operation of the steam, as used in the steam cylinder, was precisely the same as in the cylinder of any other steam engine. It entered the cylinder, did its work for the stroke and was discharged at the exhaust, and we have no more to do with it.

The complete cycle of operations, so far as the air was concerned, was as follows: The air first entered the compressing cylinder, where it was compressed to the required pressure, and was delivered at quite a high temperature in consequence of the compression. From the compressing cylinder the hot compressed air passed to a cooler, where it was cooled to the temperature of the water that circulated in the cooler. The cooled air then entered the air-driving cylinder, where it was used precisely as the steam was used in the steam cylinder, and helped by its pressure to drive the machine, the work done by it being to that extent a distinct saving of power. The air was then discharged from this cylinder at a greatly reduced pressure, and consequently at a very low temperature. Although from this point the conveying pipe was thickly inclosed in non-conducting material, the cold was so intense that around the exhaust passage a thick external coating of ice was formed by the condensation and freezing of the moisture of the external atmosphere. The air was then conducted as directly as possible, and in pipes thickly covered all the way with non-conducting material, to the pipes embedded in the earth, to be frozen where the temperature of the air was raised by the abstraction of heat from the earth. This transfer of heat from the earth to the intensely cold air of course constituted the freezing process that was desired to be accomplished. The air, after circulating in the earth-buried pipes, and absorbing as much heat as possible from the earth in the vicinity of the pipes, emerged from there at a considerably higher temperature than that at which it was exhausted from the working cylinder; but as it was still colder than the external air, the pipes here also were covered with non-conducting clothing all the way back to the compressing cylinder again. The air then entered the compressing cylinder, was compressed again, and the cycle of operations went on.

The only part of this cycle of operations that it is necessary for us to notice particularly is the use of the air in the working cylinder. The air came to this cylinder at normal temperature, or at about the temperature of the outside atmosphere, but it was discharged from the cylinder intensely cold. Although a slight loss of temperature may have occurred on account of the work actually done by the air in driving the piston, the great cooling was on account of the expansion of the air and the increase of volume between the entering and the leaving the cylinder. The most important function of the cylinder in connection with the refrigeration was in providing the means of expansion without subjecting the air to friction during the expansion. So far as a cut-off was operative, and expansion occurred in the cylinder itself, that expansion of the air would be without friction, and the fall of temperature would coincide with the theoretical figures. So when the exhaust took place, and a still further expansion occurred, a large free passage was provided; there was little friction, and here, too, the fall of temperature occurred as expected.

In the case of discharging compressed air at normal temperature into the atmosphere, or from a high-pressure chamber into a low-pressure chamber, by means of continuous flow through fine, tortuous or choked passages, the friction of the air through the passages tends to largely defeat the intended purpose by heating the air as it escapes and preventing to a large extent the expected fall of temperature. An intermittent discharge from one chamber to another through a large free opening gives a very different and a much better effect, and some device that will accomplish this seems to be a necessary part of a successful apparatus employing compressed air for refrigeration. The air undoubtedly furnishes the possibility of refrigeration, and its use in an engine for motor purposes enables it to perform two services at once, and at the same time to give better results for the latter than when not employed for the former.

In the employment of compressed air for earth-freezing referred to above, the same air was used over and over again, the little loss that occurred through leaks at the stuffing boxes being made up by a small auxiliary pump or compressor. This arrangement was necessary for two reasons: First, because the air returning was still colder than the external atmosphere; and secondly, because the constant use of a new supply of air would have caused an accumulation of moisture deposited in the pipes, which would have frozen there and ultimately have choked them up completely.

In the use of air, for refrigerating purposes, from the public supply proposed, the air would have been drained of a large proportion of its moisture, but there might still be sufficient to make it necessary to provide some special devices for disposing of it in cases where an unintermitting refrigeration was to be maintained.

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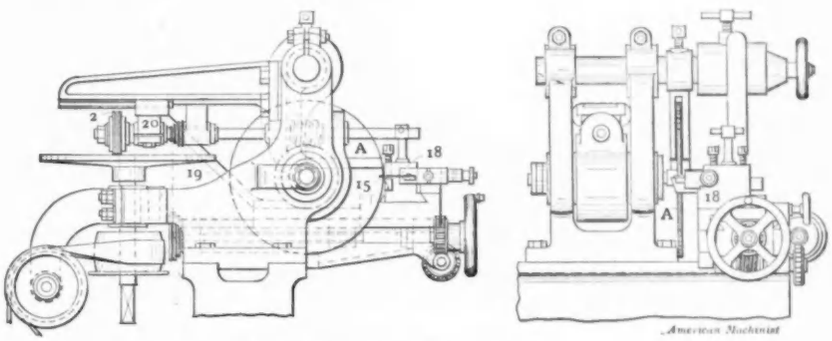
How the Steel Wool is Made.

The description of "Steel Wool" which appeared in our columns a short time ago made trouble for some of our readers, who immediately found themselves studying up different devices by which the shavings might be made. One poor fellow at least was struck quite badly by it, and has had no perfect rest up to the present time, so it will be proper for us to put him out of his misery, which is an easy thing to do.

He got up quite a number of devices, in his mind, not one of which made any near approach to satisfying him. His idea all through contemplated a solid cylindrical surface, turned true and smooth to begin with, and then attacked by a lot of V-tools, each cutting its own little shaving. As the V-tools could not be placed close enough together, there was to be another row of tools to cut later, and so placed that they would split the previous cut. Then for another device he had a gradually closing die, precisely like a screw-cutting die, but with means provided for preventing any longitudinal advance while the cutting was going on. Here he would have a great number of cutting points, each making its own shaving, but they would have a poor chance of flowing away without getting badly broken or tangled up. Then he thought of a flat, round plate with teeth like a circular saw, or rather several of them, set with the teeth staggering, and cutting not like a saw, but with the side of the tooth against the re-



MAKING STEEL WOOL.

volving metal. These were to be mounted on ball-bearings so as to turn easily, and set with a slight inclination so that they would turn slowly while the cutting was going on.

Probably some other inventors who were attacked had schemes equally wild as these, and some no doubt had better ones. The schemes mentioned were essentially wrong in starting with the V-tool, which is one of the worst, if not the worst, of all the cutting tools for the production of chips. It makes few chips and it wears very fast, while it is evident that the steel wool must be cut cheaply and rapidly, and with a tool or tools that wear slowly and do not require frequent grinding.

The actual arrangement employed for making the steel wool seems to put both the material to be cut and the cutting tool under the very best conditions for easy cutting and for the maintenance of the cutting edge. A single cutting tool, as there used, will easily cut a hundred times as many shavings as a hundred V-points will cut, and the regrinding and resetting of the tool is one of the simplest of operations. A single sentence tells the whole story, and then, as in so many such cases, the wonder is that everyone did not think of it at once. Circular disks of sheet steel are clamped tightly together and slowly revolved, and the shavings are turned off the edges of them with a sharp tool with an edge covering all of them at once. The grade of shavings produced is determined by the thickness of the sheet metal and the rate at which the tool is fed. The shavings, of course, have the best possible chance to flow away without being broken up. When the essential idea of the operation is caught, there is nothing more about it that is necessarily of interest to our readers, so we need not now trouble them with any minute details.

The cut shown herewith gives a very clear idea of the construction and operation of the machine used for this work. The large friction disk upon the vertical shaft at the left of the cut, which is the back of the machine, is driven by any suitable means, as by the quarter twist belt shown, and gives motion to the machine. A friction wheel upon the horizontal shaft is driven by this friction disk, and upon this shaft is a worm which rotates the sheet-metal plates *A* from which the shavings are to be cut. The cutting tool 15 is seen in contact with the edges of the plates, and a guard or guide 18 is placed over the tool to prevent the accumulation of shavings and make them flow off out of the way. The main horizontal shaft also carries a small cone pulley which is belted to another cone pulley below, the speed changes here made determining the feed and the grade of shavings produced. The second shaft carries a worm which drives a short cross-shaft, and this in turn carries another worm which drives the feed screw. The feed screw is provided with a clutch for throwing it out of gear and turning by hand when required. The tool carriage is connected by the tie 19 with the sliding box 20, so that as the tool feeds inward, reducing the diameter of the plates, the sliding box and the friction wheel 2 are moved outward on the face of the driving disk and a nearly uniform speed for the periphery of the sheet-metal plates is maintained. The machine requires very little attention, and one man can run quite a number of them.

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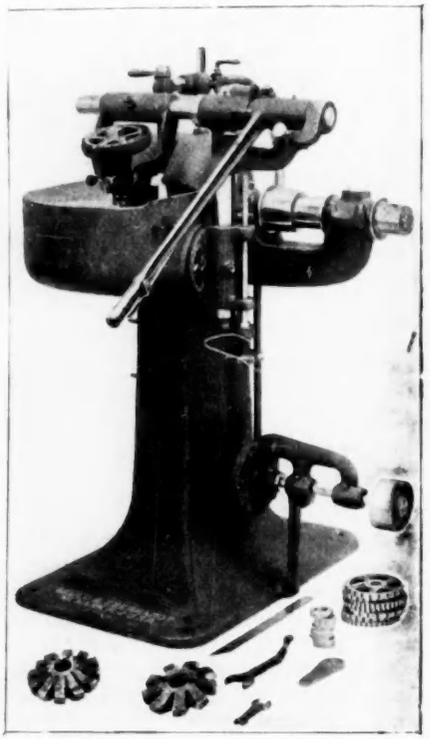
Gear Cutter Grinding Machine.

Anyone who has had much to do with what are known as patent relieved gear cutters is well aware that there are some special difficulties connected with their proper grinding, such as the liability to grind one tooth more than another, or to grind the front faces of the teeth otherwise than radial, the result of such grinding being that the exact form of gear tooth



GEAR CUTTER GRINDING MACHINE.

desired is not secured, and that an unequal amount of work is done by the different teeth of the cutter. These difficulties manifest themselves the more plainly in the case of automatic gear cutting machines, which, as is now largely the custom, are often driven to their full capacity, making it necessary that the cutter should be able to render the best service in order to stand the work. Some considerable experience with such difficulties has led to the design and construction of the machine which we illustrate herewith. This machine consists essentially of a spindle upon which are fixed two beveled-edge grinding wheels of emery or corundum, the one wheel being beveled right-hand and the other left hand. The cutter to be ground is placed upon the end of an arbor, the upper end of which has fixed to it an index wheel with a number of notches corresponding to the number of teeth in the cutter to be ground. Some of these indexes are to be seen on the floor at the right of the machine, and one of them upon the arbor referred to. This arbor passes through a T-shaped casting which is pivoted to one of the arms extending downward from the sleeve, which is seen attached to the horizontal shaft which passes across the machine at the top This shaft can be given an oscillating motion by means of the lever seen at the right, which is provided with a pawl and ratchet for the sake of securing a convenient position.

The end of the arbor which takes the cutter to be ground can be turned up toward the operator, and the cutter being secured to it, it is then turned downwards, bringing the index at the top. The cutter and the index wheel can then be slightly rotated by means of the knurled screws seen in front just below the index wheel, and the face of a cutter tooth can thus be brought into contact with the running wheel. The cutter is then swung forward toward the center of the wheel to the required depth, and a stop is set, thus defining the position of each tooth of the cutter accurately.

The wheels are placed within the tank formed at the top of the machine in order that the cutter and the wheel may be flooded with water, and this is done by means of the pump shown at the side, which delivers water to a nozzle between the two grinding wheels, which nozzle delivers two streams, one directed upward and the other downward, the cutter passing between them; and the quantity of water is so abundant that rapid grinding can be done without danger of heating.

For the ordinary or smaller cutters, but one grinding wheel is required; but in the case of very large cutters, where the cut between the teeth does not pass clear through, it is necessary to use both wheels, turning the cutter over upon the arbor to grind the second side after the first is finished. The machine is found to be efficient also in the case of gangs of cutters, and by its use it is easily practicable to secure uniform results in such gangs. The machine is made by Gould & Eberhardt, Newark, N. J.

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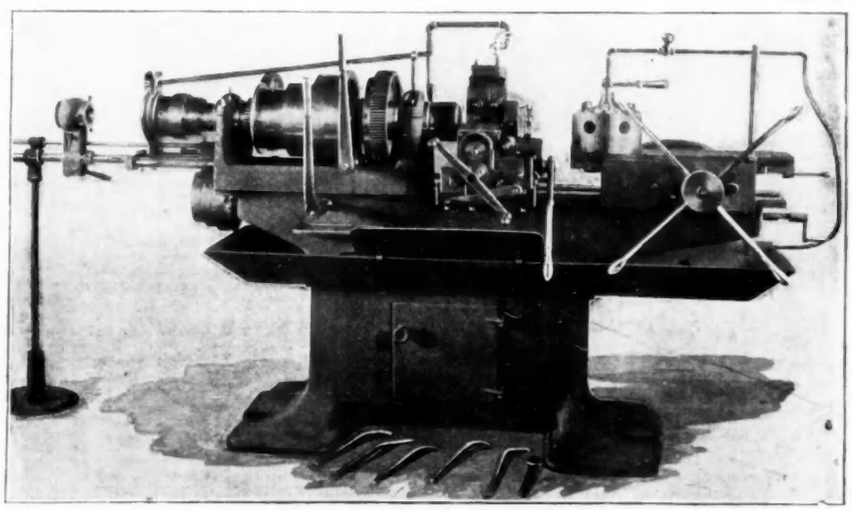
For the maximum horse-power of a shaft some persons use the following: Multiply the cube of the diameter in inches by the turns per minute and divide this by 205 for cast iron, 110 for wrought iron and 82 for steel. The quotient is the horse-power of the shaft.

Bicycle Hub-Forming Machine.

The accompanying illustration is of a new hub-forming machine especially for bicycle wheel hubs, which is being introduced by the Prentiss Tool & Supply Co., of New York. The machine is essentially the same as others of its class, but has some new features which may be of interest.

The rod feed is, in principle, the same as the Parkhurst, and is operated by the lower one of the two vertical levers seen in front of the headstock. The usual ratchet teeth of this feed are not used, however, but there is a friction pawl or cam which locks at a given position after it has been drawn up by the upper and smaller of the two horizontal rods which pass through the traveler.

The chuck is of the usual split collet variety, and is operated by the machine itself, instead of by a lever in the usual way. This movement is effected by means of the rod which passes longitudinally at an angle over the cone pulley, and when this rod is rotated by means of the small handle inserted in its upper end, it rotates two small eccentrics fixed to its other extremity, these eccentrics pulling together and thereby tightening a clam shell friction clutch which passes around a sleeve which ordinarily rotates with the spindle of the machine, but is threaded internally, and, when prevented from rotating by this friction clutch, forces the tightening sleeve forward by means of the internal thread referred to. The collet is loosened by reversing the machine and again closing the clutch.



On the carriage there are four slides, the two main ones are over the center carriage and operate the forming tools which are moved up to the work by screws, one of which is placed vertically over the other, and they are of the same pitch; but one is operated slightly faster than the other by reason of the fact that the spur wheels which connect them are unequal—this different rate of driving causing the finishing tool to overtake the roughing tool as the hub approaches its finished size. The back or finishing tool is placed nearly vertical, and its upper surface is given the desired contour for the hub, so that it can be sharpened by grinding across the end indefinitely without changing its form. At the right of the forming tools is a small slide to which are attached the two halves of a rest which are closed upon a finished hub not yet detached from the bar, which hub is then operated upon by the tools in the turret if desired, and is finally cut from the bar by the smaller slide shown at the extreme right of the carriage. The forming tool slides have an automatic feed and automatic release and there is an automatic feed also for the turret slide, the turret revolving automatically as it is moved backward. Passing through the bed are two screws, the squared ends of which are seen projecting at the foot of the lathe. One of these moves the turret block upon the bed, the other the carriage. At the rear of the machine is a pump which supplies lubricant.

Technical Books.

"The Steam Navy of the United States." We have before us a copy of a book bearing the above title, the author of which is Frank M. Bennett, a Passed Assistant Engineer in the United States Navy, and not entirely unknown to our readers. As stated on its title page, the book presents a history of the development of steam power as a military appliance in the American Navy, into which history, as a necessary part of it, is woven the story of the beginning, growth and vicissitudes of the engineer corps of the navy. Many books have been written on naval subjects; but so far as we know, no special work has hitherto been prepared in any country dealing solely with the influence steam engines and engineers have exerted upon the methods of naval warfare. In this regard the book is unique and important, and will, we predict, find a place in public and private libraries, in government and industrial offices, and in the hands of all progressive officers and citizens who have any interest in our navy and its mechanical appliances. In the beginning, the author describes in detail the first steam vessel of war ever built, which was the "Demologos," designed and built for the United States Government by Robert Fulton as long ago as 1814. Following thereafter in orderly sequence, he brings to life again with pen and pencil the rude steam fabrics of early days, and so on, step by step, until the great battle-ship of to-day is evolved from the preceding forms, and is very properly described as Robert Fulton described his invention—a "steam battery." The "Fulton" of 1837; the "Mississippi" of 1842; the "Powhatan," "Susquehanna" and "San Jacinto" of 1850; the great steam frigates and sloops of war of 1855, of which the "Merrimac" and "Hartford" were types, and the smaller sloops of the same period, like the "Dacotah" and "Pawnee," all pass in review before the reader in picturesque and interesting procession. The sloop-of-war "Niagara," the ship that laid the first Atlantic cable, is described in detail with a full-page picture, and a chapter is given to John Ericsson and his "Princeton," which was the first screw-propelled vessel of war. Then comes the Civil War period, with its revolution in naval architecture, brought about by the performance of the "Monitor" and the demand for swift cruisers, and we see again the grim iron wall drawn around Charleston harbor by John Ericsson's turrets, and the record-breaking trial trip of Isherwood's "Wampanoag." The opposition of the old school of navalism to the introduction of these new types of ships, in which steam was given predominant space, is not overlooked, and the culmination of the strife between the sailor and the engineer is told in a chapter giving the official record of the famous DuPont-Stimers controversy, from which the engineer and his mechanical innovations emerged signally victorious. The competitive trials of the first swift cruisers—the "Wampanoag," "Madawaska," "Idaho," "Chattanooga," etc.—is still told in a very interesting manner, and the once notorious Algonquin-Winooski rivalry is revived for the information of the present generation. Then comes the story of the decay that fell upon our navy in the twenty years following the war, redeemed later by the account of the public awakening that caused the beginning of the "New Navy." The author tells everything worth knowing about the personnel of the naval engineer corps; who the first engineers in the navy were; how they were appointed and graded; how they were dignified by being exempt from flogging (!); how patiently and persistently they multiplied the fighting capabilities of the navy, by forcing the adoption of their machines upon a conservatism so hidebound by tradition as to be blind to its own in-

terests; and how nobly they, both regulars and volunteers, took their proper place as combatants in the naval organization when war came upon it. The several chapters relating to the Civil War are of absorbing interest historically, and should bring shame upon those modern naval reformers who airily refer to their engineer comrades in arms as "non-combatants." From the records of the Surgeon-General's office, reproduced in this book, it appears that during the four years of the war no less than one hundred and fifteen engineers of the navy were killed in battle, or died of wounds or disease incident to the service, and the author prints a table containing the names of more than one hundred engineers killed or wounded by violent means, a majority of them by gunshot wounds, during the same period. One chapter describes, with colored plates, the uniforms and corps devices worn by the naval engineers corps from 1837 to the present day; another, with numerous pictures of cadets, tells of the beginning, growth and destruction of the admirable cadet engineer system at the Naval Academy; and yet another describes the impetus given to technical education in the United States by the naval engineer corps. All who admire heroism, and the rugged physical and moral qualities that mark men of action, will be charmed by the chapter devoted to Arctic exploration, in which the deeds of Chief Engineer George Wallace Melville are told again in striking prose. An appendix gives in tabular form the names and record of service of all who have been members of the corps of naval engineers. Another appendix presents a table with the names and dimensions of all steam vessels of war ever built for the American Navy; this table represents an immense amount of labor in collecting data. A third appendix, entitled "Uncle Sam's Whistle, and What It Costs," reproduces a war-time satire dealing with the Isherwood-Dickerson controversy regarding the remarkable machinery of the "Pensacola." There are a great number of full-page half-tone plates presenting portraits of the different engineers-in-chief of the navy and other distinguished engineers, and showing examples of practically every type of war steamer our navy has ever possessed. In addition to the plates, the text is greatly assisted by a large number of cuts showing vessels and machinery described, different types of engines, boilers and screw propellers, old and new, being shown in this graphical manner. The style of this work is that of a popular narrative, suitable for the general reading public, rather than technical, and it can hardly fail to interest all who see it. Either to read as a narrative or as a reference volume, this will be found a book of great value to all who are at all interested in either naval or engineering matters. It contains 953 6 x 9 inch pages. Cloth, $5.

Letters from Practical Men.

Tools for the Planer.

Editor American Machinist:

I happen to be running a planer on a variety of work, and I am not satisfied with the way I do some things, and I would be glad if you could put me in the way of doing them better. For a starter, could not you or some of your readers tell me the best way of holding thin flat pieces on the planer? Then, say that I have a piece like the sketch, Fig. 1 (this is the end of it), are there any braces, as *A* (which is a piece of wood), that can be lengthened or shortened for different sizes of work? Please give sketch of tool holder for planer, one that can be clamped in the usual way in the head, and use a small tool first for planing the top, and then the same tool to reach in under and plane at *X*. It might not be the same tool, but I mean a little tool only an inch or two long, that would clamp into a holder and be set around in different positions.

JUNIUS.

["For a starter," we can mention a device for each purpose, and then if anyone will do better we will thank them. One at least of the devices has been in the columns of the "American Machinist" so many years ago that it may be new to the present generation of young machinists.

When we first had anything to do with a planer, taper stakes and square holes were the fashion, and the planer man never hesitated to drive them into the platen with all his strength in fastening down a piece or in bracing it properly. It has dawned upon a later generation that a stake should never be driven into a planer platen, that no hammering should ever be done upon it, and that all possible care should be taken to avoid pening or stretching the surface and springing the platen out of true.

If the platen has round holes in it, then a part of its outfit should be a lot of stakes like the sketch, Fig. 2, made of square iron or steel, with a stem turned to nicely fit the holes in the platen, and the head drilled and tapped for a horizontal screw, and a screw in it with a hardened conical cup end. If the holes in the platen were ¾ inch, then the head of the stake might be 1¼ inches square and, say, 1½ inches high with a ⅝-inch set-screw. Then, in connection with these stakes, there should be a lot of round steel pins of different lengths, say 5-16 inch diameter, or larger if long, and ground to a point on each end

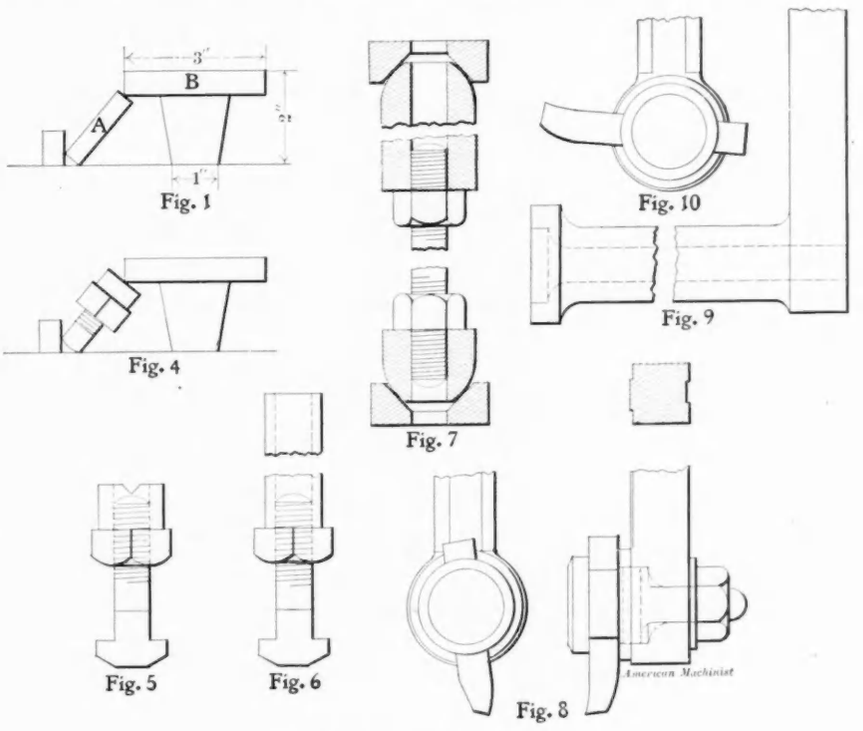


Fig. 1 Fig. 4 Fig. 5 Fig. 6 Fig. 7 Fig. 8 Fig. 9 Fig. 10

SOME PLANER TOOLS.

and hardened, not too hard. When provided with these we have never had any difficulty in holding quite thin pieces on the planer, and they are handy for pieces of many other kinds and shapes.

Say that we have a piece *A*, Fig. 3, ⅜ inch thick, and we want to plane the whole surface of it. We suppose that one side has been planed, or, if not, that it is packed up with thin shims, so that it will have a good solid bearing without any springing down away from the cut. We merely place it on the platen where most convenient, set a number of the set-screw stakes around it, and with the pointed pieces as shown, one end of each against the edge of the plate, and the other end in the cup of the screw, tighten them up gently and equally all around, and the piece will be held firm and secure and without springing. If the plates to

be planed are of large surface, there may be a tendency to spring up in the center, which can, of course, only be overcome by having a bolt and a long strap to reach in to near the middle of the plate, substituting another strap on the other side when the tool gets to the middle. The set-screws do not require to be set up very tight, as the work is held by a very slight pinch. A little experience in the use of them will bring confidence and appreciation, and judgment also about tightening and adjustment. The screws in front that take the end thrust should be rather tighter than the others, and the points of the front pins should be well bedded, and it is well to try the back screws once or twice to see that the slack is taken up if the front points happen to yield. The side pins and screws should usually be set with a slight angle toward the front as shown, and the pointed pins should be used as long as possible, so that the end of the set-screw will not project far beyond the level of the stake. With the round stems to the stakes, if the set-screws and the points are not exactly in line, the stake is apt to swing around and let go entirely, especially if the end of the screw sticks out very far. For planing very thin plates, the pointed pins may be flatted off on one or both sides if necessary to keep out of the way of the tool. The stroke of the planer should be adjusted carefully so that the tool will not strike the pointed pins.

Now as to braces and vertical supports for work on the planer. A variety of work, or even a range of work that is not very wide, usually calls for an assortment of these, and a planer should be liberally supplied with them. Wooden blocking is only a substitute or a makeshift that is not to be depended upon, and that does not give absolute rigidity. In the case proposed by our correspondent as the allowable length of the brace is small, a half-inch set-screw with a threaded nut and a loose nut or washer would answer the purpose very well (Fig. 4). The set screw may be as long as will just clear the corner of the casting when the head of it is in the angle formed by the side of the stake and the surface of the platen. The nut should turn easily on the screw, and it should be run down so that the screw may be set in place, and then the screwing up the nut will set the collar up tight against the work.

The planer should have a good set of bolts of different lengths, with long threads on all of them, and they can always be used either for vertical supports or for inclined braces when required. Having the bolts and nuts, and usually also an assortment of washers of different lengths or thicknesses, there should be no trouble about improvising supports or braces for almost anything (Fig. 5). If long braces are required, pieces of iron pipe may be used with a bolt and nut, or set-screw and nut, adjustment for one end (Fig. 6).

The most unsatisfactory thing about these improvised supports or braces is that we don't get a good square bearing for the end of them, and that gives a chance to go on refining as much as we please. If we get a lot of washers and sleeves or long collars cast like the sketch, Fig. 7, and then some straight pieces of round iron with long threads on both ends, we will have no trouble about the end bearing, and the making of them will not be expensive or call for any fine work.

For an adjustable tool holder for the planer, the one we show is a good one, and while by no means new, it should be better known and more generally used. It is not only good for all kinds of special work, but it is good for all the everyday work of the planer, and with it and a few small tools of all the usual forms, a very wide range of work may be done. By slacking the nut at the back the tool is instantly released, and it may be swung around at any angle and slipped in or out as required, and then the tightening of the nut makes it firm instantly. The same tools may also be used in the extension holder, Fig. 9, for keyseating or any other kind of internal work.—Ed.]

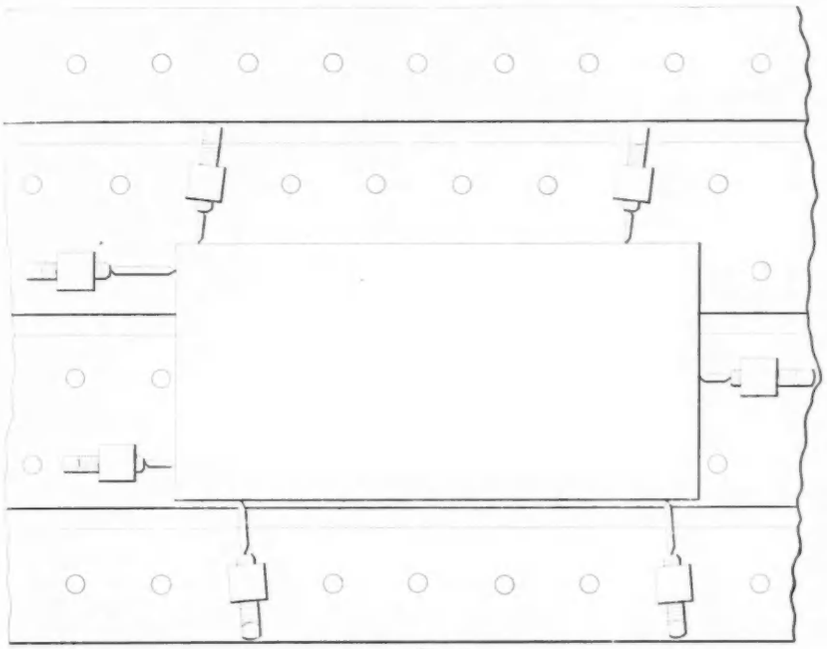


Fig. 3

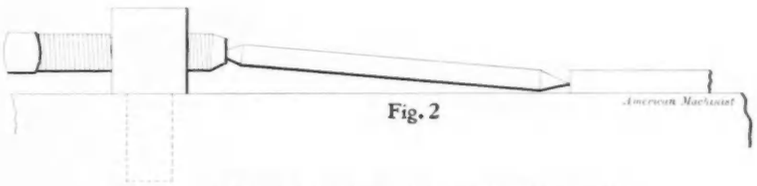


Fig. 2

HOLDING THIN WORK ON THE PLANER.

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Star Feeds—Grinding Machines—Scrap Heaps—Grinding Milling Cutters to Avoid Revolution Marks—Ball Bearings for Grinding Machines.

Editor American Machinist:

In your issue of October 22d, page 1001, Tecumseh Swift says it seems queer to him that the De La Vergne big boring mill has a star feed on its boring-bars. I don't see why it is any more queer for the De La Vergne shops than for the Niles Tool folks, who use the star feed often enough, as do many other builders of machine tools, in certain places. In the De La Vergne boring mill the simple star feed is made to give a great range of feeds to the boring head, and also feeds the head both ways, and I don't see anything queer about it, except that so little machinery should give such a lot of changes.

Again, in the issue of November 3d, page 1046, Tecumseh Swift asserts at the outset that "We can't be too careful about our promises," and then he shows two forms of grinding mills and says that the one shown in Fig. 3 is an efficient coal pulverizer, and that Fig. 4 is some Mr. Smarty's improvement that wouldn't grind anything. Now, the fact is that No. 4 is a well-known and most efficient form of grinding mill, regularly listed in

catalogs of makers of such machinery.

As to James Watt's scrap heap, which Tecumseh Swift and others mention, I think, if memory serves me correctly—though as it is some years since I last read the life of that great man I may be wrong—that Watt spent much more time on the rotary or "wheel" engine, as he called it, than he did on the common form of cylinder and piston engine, and if anybody can make scrap faster than by building rotary steam engines I don't see how they manage it, that's all. James Watt was like every other mortal man, wise engineer though he was, and the only men who don't make mistakes are those who never do anything.

Ernest McGrath, August 6th, page 751, says the mill "revolution mark" is due to the wear of the emery wheel in grinding the teeth of the mill, because the mill wears off a little with each tooth ground, thus leaving the first tooth long. He says the difference may be as much as "two thickness of paper," which is 0.002 inch in thin tissue paper. If Mr. McGrath will try the experiment of grinding twice or three times round a mill, he will find that the mill doesn't have a long tooth. Again, Mr. McGrath speaks of a mill as taking a "strong grip, thus drawing it closer to the work," and adduces a planer cut in support of this idea. A planer cut is not a mill cut, nor in any way similar to it, and mills don't dig into work, as a general thing; they push away from it, and push away mighty hard, too, even with a big "front rake" angle to the teeth.

"Quirk," August 20th, page 790, takes a more rational view of the revolution mark; but, curiously enough, Jerry Moffitt, of Providence, R. I., a town where machinists ought to know a lot about milling, accepts the "long tooth" idea of McGrath's, and advocates grinding every fourth tooth of a mill until all are ground, and says this method of grinding would cause a mill to make four revolution marks to each revolution made by the mill! This whole revolution-mark matter was fully discussed in the "American Machinist" a long time since. No one has yet used a mill which did not make one distinct mark for each revolution, no more, no less. A side cutting mill may be ground in place in the machine until the teeth "indicate" true, which means a variation in tooth length too small to be measured, and it will yet make a revolution mark; just why no one has yet told, to my knowledge at least. Probably many readers of the "American Machinist" have forgotten the articles on "The Revolution Mark," but the revolution mark stays on all milled work just the same, and seems likely to remain in evidence. It may not be very deep, not over 0.0001 inch, but it is very plainly visible on all work finished with a side cutting mill.

A still less to be expected obliviousness of a "practical" correspondent is to be found in this paper, November 26th, page 1111, where A. W. Parkhurst says this paper has not yet noticed the application of ball-bearings to high-speed journals, and goes on to say that he has designed a machine for grinding cycle ball cups, which has the wheel spindle running on $\frac{3}{16}$-inch balls. In its issue, May 21, 1896 page 517, the "American Machinist" printed a full description, with both halftones and blueprint reproductions, of the Lozier cup and cone grinding machines, which have the spindles carried on ball-bearings. The Lozier machines, at Toledo, O., give the first examples of grinding machine spindles carried on balls within my knowledge. Cold sheet metal rolling mills are successfully journaled on rollers, not balls, at Attleboro, Mass., with a very great saving of power. I do not think I would put ball-bearings in a heavy lathe; but with roller bearings, composed of hard rolls, hard lathe spindles and hardened integral cylinder roll tracks, I am convinced lathes would give entire satisfaction. The cylindrical roller operates with less friction than balls in cycles and trotting sulkies, and is probably better than balls in all places for which its shape makes the cylinder suitable.

EASY WAY.

▲ ▲ ▲

Reciprocating Parts of High-Speed Engines.

Editor American Machinist:

I have read with interest the description of Mr. Hollingworth's engine which appeared in your issue of January 7th, in which we are told that "a weight of reciprocating parts has been secured which, at the given speed, results in a remarkably uniform pressure throughout the stroke," and I am led to express some views, which by many will be considered heretical.

It has seemed to me for a good many years that Mr. Porter's original application of the action of the reciprocating parts to equalize the pressure upon the crank pin was wrong, and as this method is the one which has been generally followed, where any attention has been paid to the matter, it follows that, in my opinion, common practice, of which this engine is an illustration, has been wrong.

Mr. Porter discovered that the inertia of the reciprocating parts could be made to absorb more or less of the steam pressure upon the piston at the beginning of the stroke, and to give it out again at the end of the stroke, and thus, to a large degree, overcome the unequal pressure through the stroke due to the use of an early cut-off. By proper adjustment of the weight of these parts to the speed, he showed how a tolerably constant pressure could be produced upon the crank pin as the stroke advanced, in spite of the rapidly falling pressure of the steam, and it is assumed, and others have accepted, that this was the proper thing to do. This he did by so adjusting matters that the reciprocating parts should absorb about one-half of the total steam pressure at the beginning of the stroke, which results in the equivalent of this half of the steam pressure being continued through the stroke to the end, when it is abruptly stopped, to be succeeded by an equal force in the opposite direction, applied with equal abruptness.

This is what Mr. Porter taught in his great work, "The Steam Engine Indicator, and the Development and Application of Force in the Steam Engine," and it is still considered by most designers to be the logical application of the action of the reciprocating parts as first disclosed in that work. Mr. Porter seems to have early changed his views as to the proper adjustment of the weight and speed, as he published in your columns for August 22, 1895, an account of some experiments made in 1870, in which quiet running was found to attend a speed such that "it [the inertia at the beginning of the stroke] amounted to more than the steam pressure." In view of the age, wide circulation and high standing of Mr. Porter's book, it is not surprising, however, that the attainment of uniform crank pin pressure, as there taught, is still understood by most engineers to be the proper thing to aim at, but I want to ask if any arrangement can be conceived more likely to lead to pounding on the centers; and if pounding was an object to be desired, how anyone could advise a method more certain of producing it?

In point of fact, the adjustment should be such that the reciprocating parts will absorb *at least all* the steam pressure at the beginning of the stroke. This adjustment would lead to the crank pin feeling no pressure at the beginning of the stroke; but, starting from nothing, it would feel a gradually increasing pressure during the stroke to the end, where the pressure would abruptly stop and be succeeded by a similar pressure in the opposite direction, beginning as before at nothing. Pounding cannot be produced by stopping the pressure, however heavy it may be, or however abruptly it may be stopped. The pounding is produced by reversing the slack, and if this is done by a heavy pressure, abruptly applied as in the usual plan, it will be taken up suddenly, which is exactly the way to produce heavy pounding. On the contrary, if taken up by a pressure which is gradually applied, we should expect little or no pounding. It seems to me the argument is unanswerable.

C. O. GRIFFIN.

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"Limit Taps."

Editor American Machinist:

I wish to call attention to some of the points in the article by Mr. Arnold, in the issue of November 26th, on "Limit Taps."

It points out very plainly some of the imperfections of taper and cylindrical taps, putting special emphasis on the truth that whenever a tooth cuts, it is dulled, and changed in form, an amount corresponding to the cutting. It then describes a tap, calling it "limit tap," that cuts each part of the groove (taps are employed to cut spiral grooves) with a different part of a different tooth. In the limit tap, no part of the cutting edge of any tooth has a corresponding part of another cutting edge following it. Therefore, when that one part is dulled—which it must be if it *cuts*—there is no tooth on the same tap that will correct the cut. Mr. Arnold seems to recognize this, for, to attain accuracy, he uses three taps exactly alike, thus providing three teeth to cut each part of the groove. He claims these three teeth following each other secure accuracy within a very small limit, and that this limit may be reduced at pleasure, by running more taps through the work.

Now, it seems to me these three taps but imperfectly attain the same end the many teeth in the cylindrical tap are designed to attain. We are told that after once cutting any metal, the teeth on a cylindrical tap are no longer of the original shape. But if three limit taps passed through work will make it correct, the three first teeth of a cylindrical tap are sufficient; the others may all be considered reserve teeth to come into action as the forward teeth wear and lose their shape. In other words, Mr. Arnold proposes to do with three teeth what he tries to show cannot be done with several times three teeth more advantageously placed.

Mr. Arnold truly says these limit taps work easier than cylindrical taps, but fails to point out that the reason is they do but part of the work intended.

WM. S. ROWELL.

Cleveland, O.

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School Draftsmen.

Editor American Machinist:

I have been much interested in your remarks on "School Draftsmen," and in the comments made on them by your correspondents. As a school man, I am willing to admit the justice of some of the criticisms made, and I think that all teachers of drawing will admit that they are not satisfied with the results of their drawing teaching, wholly. But it seems to have been overlooked that drawing is but a small part of the matter taught in the schools, and that but a few hours, and those necessarily disconnected, can be given to the work. All the same, the drawing is capable of improvement. We of the schools are anxious to make the most progress possible in the time at our command; most of the technical schools are doing all that their time will allow to familiarize the student with shop methods, both by actual work in shop and foundry and by instruction in the best methods of doing work. It is not possible, except to a limited extent, to design and construct machinery in a school shop; expense and time do not permit; but the aim should be, in all manual work, drawing, forging, turning and what not to use actual shop methods and, so far as possible, to have the work done go towards the completion of a machine or article of use. If this be done, the elements which you say are lacking, i. e., consideration of the means to be employed in making the piece which is being drawn, and cost of different methods, will naturally be emphasized in the work and will take their place in the course.

We are glad to have your criticism of our work and to know wherein it seems to be lacking. But, if you condemn our present methods, is it not a duty to suggest something better? Let us hear from you shopmen, and tell us where we can improve our courses. We are glad to adopt all suggestions which are practicable and which we can see are to be of advantage.

ARTHUR L. RICE.

Pratt Institute.

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Another Solution of Cubic Equations.

As the solution of cubic equations appears to interest your readers at present, I am prompted to send you the following solution:

Let the equation be in the form, $x^3 + p\,x + q = o$, then a roughly approximate value of x is

$$x' = \frac{-3q}{3(q)^{\frac{2}{3}} + p} = u \qquad (1)$$

substitute u in $x'' = \frac{2u^3 - q}{3u^2 + p} = v$ (2)

v is a nearer approximation. By repeated substituting v for u in (2), a very close approximation can be obtained.

The following example will illustrate:

$x^3 + 2x - 20 = o \qquad p = 2 \qquad q = -20$

(1) $x' = \frac{60}{24.08} = 2.49 = u$

(2) $x'' = \frac{50.8775}{20.6003} = 2.469$

This is the correct to the third decimal place.

When the equation is in the form $x^3 + a\,x^2 + b\,x + c = o$, $p = b - \frac{a^2}{3}$ and $q = \frac{2a^3}{27} - \frac{ab}{3} + c$, and the final value of x must be increased by $\left(-\frac{a}{3}\right)$. When $3(q)^3 = p$, equation (1) fails, but it can be put in another form.

CUBIC.

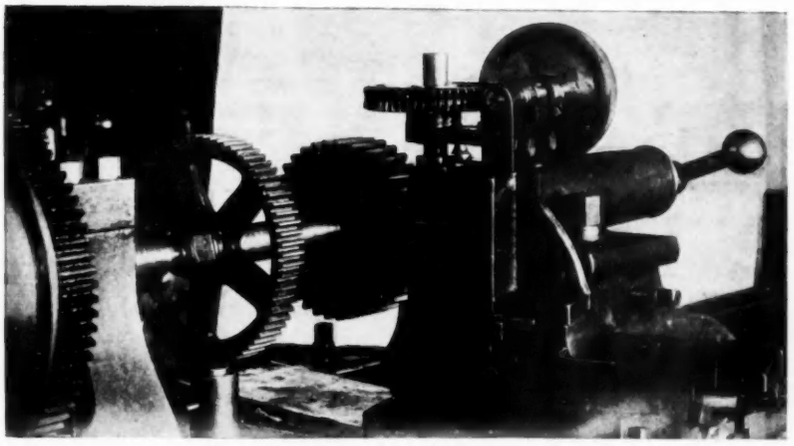
▲ ▲ ▲

Gear-Cutting Attachment.

Editor American Machinist:

I frequently hear the remark from proprietors of jobbing shops who are fairly equipped, "I wish we could afford to own a milling machine."

One of our ingenious proprietors here had twenty gears to cut, and has built the rig shown herewith. He attaches it to his 18-inch lathe, drives with ¼-inch round belt from a drum countershaft overhead, and when I took this photograph, was using a pair of 6-pitch Clough cutters, forming a tooth 1-inch face at the rate of one every 2½ minutes.



GEAR-CUTTING ATTACHMENT.

W. B. PATTERSON.

Dayton, O.

[The photograph shows the attachment placed upon a compound rest, which is swung around to an angle; whether to give a better view of the device or to make the belt lead properly, we do not know. It is to be noted also that by the method of indexing adopted, the lathe can be driven for the feed.—Ed.]

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Sizes of Collars for Shafting.

Editor American Machinist:

I would like to know, through "Questions and Answers" published in your paper, if there are any standards for collars, and if so, please mention the sizes.

RAYMOND DECKER,
Draughtsman.

Editor American Machinist:

Yours of 13th inst., making inquiry re-

garding sizes of collars for shafts, is received.

In reply we send herewith a blueprint of our Dr. 6881, giving dimensions of both our fast and loose collars for line shafting. These are the sizes that we have been using for many years past, and they seem to be in every way satisfactory.

WM. SELLERS & CO.

Philadelphia, Pa.

LOOSE COLLARS.

Name of Shaft.	Diameter of Collar.	Thickness of Coll r.	Diameter of Set Screw.	Length of Set Screw.
Inches.	Inches.	Inches.	Inches.	Inches.
1	1 3/8	3/8	7/16	5/8
1 1/4	1 5/8	13/32	7/16	5/8
1 1/2	2 1/4	15/32	7/16	7/8
1 3/4	2 1/2	1	7/16	7/8
1 7/8	2 3/4	1 1/16	1/2	9/16
2	3	1 1/8	5/8	9/16
2 1/4	3 3/8	1 3/16	5/8	5/8
2 1/2	3 3/4	1 1/4	5/8	11/16
2 3/4	4	1 5/16	5/8	11/16
3	4 1/2	1 7/16	5/8	13/16
3 1/4	4 7/8	1 1/2	3/4	13/16
3 1/2	5 3/16	1 5/8	3/4	15/16
4	5 13/16	1 3/4	3/4	1
4 1/2	6 7/16	1 7/8	3/4	1
5	6 15/16	1 7/8	3/4	1
5 1/2	7 1/2	2	3/4	1
6	8	2	3/4	1

FAST COLLARS.

Name of Shaft.	Diameter of Collar.	Thickness of Collar.
Inches.	Inches.	Inches.
1 1/4	2	1/2
1 3/4	2 1/4	1/2
2	2 5/8	1/2
2 1/4	3	9/16
2 1/2	3 1/4	9/16
2 3/4	3 5/8	5/8
3	4	11/16
3 1/4	4 1/4	11/16
3 1/2	4 5/8	3/4
4	5 3/8	15/16
4 1/2	6	1
5	7	1 1/8
5 1/2	7 5/8	1 3/16
6	8 1/4	1 1/4
6 1/2	9	1 3/8
7	9 3/4	1 1/2
8	11 1/8	1 11/16

Editor American Machinist:

Your favor of the 13th inst. to hand, and in reply would say that there is no standard for collars, each manufacturer making the collars to correspond to the diameter of the bearings against which the collar is to run; these bearings all vary more or less, according to the designs of the different manufacturers.

GEO. V. CRESSON CO.

Philadelphia, Pa.

Editor American Machinist:

We do not make collars for our shafting, but buy them. There seems to be no regularity regarding their size. There should be two standards, one for wrought and another for cast iron. We would be glad to hear that a standard was adopted.

CUMBERLAND I. & S. SHAFTING CO.

Cumberland, Md.

A number of shafting manufacturers are using Shartle's safety collars, and upon inquiry of the manufacturers of these collars, the Middletown (Ohio) Machine Company, we were given the following table of sizes:

TABLE OF SIZES OF SHARTLE'S PATENT SAFETY COLLARS.

Size.	O. S. Dia	Face.	Size of Screw.	Number of Screws.
Inches.	Inches.	Inches.	Dia.—In.	
1 3/16	2 1/2	1 5/16	3/8 X 3/4	1
1 7/16	3 1/8	1 5/8	7/16 X 3/4	1
1 11/16	3 1/2	1 7/8	1/2 X 3/4	1
1 15/16	3 3/4	1 7/8	1/2 X 3/4	1
2 3/16	4 1/2	1 7/8	1/2 X 3/4	1
2 7/16	4 1/2	2	1/2 X 3/4	1
2 11/16	4 3/4	2	1/2 X 3/4	1
2 15/16	5	2	1/2 X 3/4	2
3 3/16	5 1/2	2	1/2 X 1	2
3 7/16	6	2	1/2 X 1	2
3 11/16	6 1/2	2	1/2 X 1	2
3 15/16	6 1/4	2	1/2 X 1 1/8	2

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European Tests of Engines.

Editor American Machinist:

I feel impelled to make some reply to the communication of Mr. Harris Tabor, published in your issue of November 19, 1896, and wish to assure him and your readers that here in Belgium our engines are tested running under actual working or commercial conditions, and from two-thirds to the full load; yet, when my engines have been tested in such service as a grist mill, for instance, where the power is practically constant, the result is not better by more than 1 or 2 per cent.

Regarding the cylinders built in several pieces, they have been built in Paris since 1872, and an engine made in that way was exhibited at Vienna in 1873, and they have been built by the same maker ever since; but that does not prevent the clearance being too large, and it is, I think, too much in the Corliss and Reynolds engines for the same reason. In fact, I may say that as a result of considerable familiarity with the designs of American engines, I think they are generally open to the same objection, i. e., of too much clearance and prejudicial surface.

Regarding the troubles from broken or inoperative engines, I feel quite certain that such accidents are as much objected to by engine users in this country as elsewhere, and the business conditions here would certainly not permit a builder to continue to supply engines likely to give trouble in that way.

However, I do not see that accidents are more liable to happen with cylinders made in three pieces than with those made in a lesser number, and in the case of water in the cylinder, I have found by experience that the shutter of my engine will move backward, and thus prevent a general breakdown.

A. BOLLINCKX.

Brussels, Belgium.

The Gas Engine in Belgium.

Editor American Machinist:

I wish to offer a remark in connection with the article upon "Development of Gas Engines Abroad" in your issue of December 10th. In Germany the gas engines are preferred, but in Belgium, where much progress is made in machinery, the gas engines are declined. This is not on account of their consumption, which is indeed pretty well reduced, especially when the engines are used by gas makers, who can supply their engines with their surplus gas, which costs next to nothing. After trials of four or five German and English gas engines, the Co. Eclairage du Centre, a powerful company supplying light to the city of Ostend, has given up those engines on account of their irregularity and tediousness, and has adopted steam engines of our system (Bollinckx).

I, however, must say one thing: In England and in Germany, where the steam engines are not yet built with the improvements prevalent in Switzerland and Belgium, the gas engines have been making great and rapid progress, while in both the latter countries the first place is given to the steam engine, and I believe this will be so until the gas engines have been greatly improved.

S. WALTON.

Brussels, Belgium.

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"Credit for Shop Improvements."

Editor American Machinist:

In the "American Machinist" of November 19th an article appears under this title which will stand further discussion. It tells how the originators of shop improvements are rewarded in a Baden manufactory of implements.

This is a subject I have often considered, but during my experience of twenty years have yet to see the first instance where improvements in machine shops are ever paid for, or even, with rare exceptions, gratefully received by anybody. Even criticisms of methods and offered suggestions passed between workmen, end in ill-feeling more often than otherwise.

As a general thing, improvements in methods come naturally from the men doing the work, and are more frequently spontaneous or "just thought of" than results of deep or prolonged study, and their common reward, from foreman, superintendent or proprietor, where of any account, is generally an approving nod, a remark of "that's good" or "great head you've got." I fixed up a little machine in a shop I had charge of a few years ago, for boring bolt holes in place of hand work on ironing coal cars. Although this thing gave the shop an advantage over competitors in their locality by some two dollars a day in labor cost, I never got so much as a "thank you, ma'am" for it, and always believed the "old man" felt more like kicking himself for not having

thought of it than he did in remembering that any credit was due me; and in other cases, when telling of some new scheme, have actually been "jawed" for not having suggested it sooner.

So far as my experience goes, proprietors seem to feel that when a man draws his pay he is getting paid for everything he is capable of doing connected with the shop. This is all right from their point of view, but does not induce men to rack their brains much. Whenever a man makes a discovery, its disclosure to the foreman, superintendent or "old man" is always prompted by hope of recognition in some way—by promotion, praise, or to pave the way to a raise of pay. Every man has his share of vanity, and loves to display his gifts and accomplishments, and if he can't get shekels he'll accept thanks.

In the case of these Baden manufacturers, the article states that owing to the improvements they were able to lay off 20 per cent. of the men, and of the money thus saved they divided part of it among the men remaining. Why didn't this company lower their price on the machinery produced, to put it in reach of more customers, thus benefiting the public, which would have enlarged their plant, not only giving them more profit, but giving employment to more men, instead of sending some out to help lower wages in other shops?

It is farther stated that in some shops the men "merely do what they are told," but suggest nothing. That is also what the men do in the army and generally with pretty good results. If there is a good foreman who knows how to turn out good work and make it pay, any concern will find it won't do to force him to consider instructions from every Tom, Dick and Harry around the place, and a workman who has sense enough to do what he is told can always be relied on, and will in all cases be better appreciated and keep his job longer than the man who is always trying to instruct his foreman. The assumption that all suggestions from the men are improvements is very far from being a fact; and furthermore, there are always men in a shop who criticise every move made by the foreman and always have a lot of idiotic suggestions to offer, taking offense when they are ignored, saying, "Suggestions don't go here; the boss is one of your know-it-alls."

Suppose a man who is working in the shop, has held good positions before, and actually is a better man and could conduct the shop better than his present foreman, can anyone blame that foreman for hanging onto the source of bread and butter for his wife and babies? I guess not. He has sense enough to try to feed his family even if he don't know enough to run a dirty little machine shop. For just as sure as it takes money to pay rent, the best man will win in time; and the only thing for the time being for that foreman to do, is to ignore or pirate that man's suggestions, or fire him out on some pretext. If the "old man" found out he could derive any benefit from changing foremen, he'd change every day. But the man who happens to be chain-lightning on improvements isn't qualified in all cases for a manager; many men don't know any better than to spoil a two-dollar jack-knife in making a ten-cent kite; have no idea about the commercial side of shop improvements. I once knew a man who was fitting up a bicycle factory to spend $43 getting up a grip for a spoke threading machine before he knew whether he was capable of building a bicycle after he had the spokes threaded. I said to him: "Why the deuce didn't you buy a twenty-five cent hand vise to try that thing with?" Well, the "old man," who was putting up the money never turned out a single bicycle, blowed in his pile and gave it up.

May the Lord deliver me from a man who never can do what he is told without getting in his eternal: "Don't you think, Mr. Foreman, that it would be better"—yop, yop, yop, etc., when nine times out of ten he'll "ball' up the job under *any* circumstances.

The best thing for any foreman to do is to tell his man what he wants done, and, if necessary, when it is to be finished; in case he has any doubts as to the man's ability to perform the work successfully, he should ask him to describe how he is intending to do it, and if the foreman discovers any flaw in the plan, he should show the man where he is wrong, and they should come to some definite conclusion together; good suggestions ought to be received in the same spirit they are given in; it is a matter of courtesy. If a foreman can't keep at the head he don't belong there, and sooner or later must return to the ranks until he becomes more proficient.

Another place in the article referred to says: "Sometimes narrow-minded foremen stand in the way of improvement by repelling and antagonizing good men, thus making shop management a failure." It generally happens that there are more ways than one to skin a cat, and when it comes to a choice it won't pay any shop to have ill-feeling aroused by letting it be understood that there is an appeal from a foreman's decision in a choice of methods; that is a thing which makes the foreman wish he had another job.

There is no such thing as running a shop successfully with half-a-dozen men in equal authority; each one will be trying to climb on top of the others, like rats drowning in a tub. Once let it be understood in a shop that superior ideas in tools will be rewarded by the foreman's job, and the job will change hands twice a week, and the shop will soon be in the receiver's hands. Every other consideration would be side-tracked by the men while they were fighting for the boss's job. I was superintendent of a big shop one time for six straight months, and was the ninth man they had used up in two years.

The idea of having all men turn into the office a written statement of suggested improvements, with the understanding that there would be rewards of merit in the shape of cash, may be a good thing; looks like it, and its outcome can be determined by experiment. There is plenty of chance for rewards in this line; for, as a general thing, the bigger the shop, the more rotten the details, and what I have seen leads me to believe that not one shop in ten realizes more than 75 per cent. of possible profit.

W. H. CHAPPELL.

Harvey, Ill.

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A novelty of the present season is the self-sharpening skate. The blade of the skate is made of two thin outer sheets of high-carbon steel with a central piece of soft steel, all, of course, welded into one. As the outsides of the blades are hardened and wear slowly, while the center remains soft, the latter wears away as fast or faster than the outside, and the concavity of the tread is maintained.

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By the most improved thermo-electric methods the melting points of several metals have been recently determined as follows: Copper melts at 1,095 degrees Cent., or 1,939 degrees Fahr.; silver melts at 970 degrees Cent., or 1,714 degrees Fahr.; platinum melts at 1,759 degrees Cent., or 3,134 degrees Fahr.; and aluminum melts at 660 degrees Cent., or 1,156 degrees Fahr.

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There is a report to the effect that the board which is to have charge of inspection of material for naval vessels is hereafter to be controlled by the construction and engineering department of the navy, and that line officers, who, of course, know little about such matters, are not to have charge of such work, some costly experience having led to this change.

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Five young Chinamen have been employed at the Baldwin Locomotive Works, Philadelphia. It is expected that they will return to China, and that they will do good service for us in promoting the efficiency of the American locomotive there. The Baldwin Works, it will be remembered, are now building eight locomotives for the Chinese Government.

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"The National Engineer" is the name of a new journal which announces itself as the official organ of the National Association of Stationary Engineers of America. It is devoted to discussions of subjects specially interesting to those in charge of stationary engines, etc. It is standard size, 9 x 12 inches, and is in other respects up to date.

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One-Sided Reports.

Technical literature, whether in the periodicals or in permanent form, consists to a large extent of narratives or statements of what has been done or what is being done in the various lines of investigation and activity. Much of the matter has only an ephemeral existence, but still has its effect as it flows along. Much more comes to us in the shape of formal statements or reports of actual tests or experiments, and is stored for future reference. It is often, if not generally, a most difficult task to determine, even approximately, the weight of authority to be accorded to matter of this character. Even when clear and precise in statement, which it often is not, it evidently carries various and indeterminate degrees of credibility on account of the large predominance of the human element. There is probably no other place where the personal equation should be assigned so high a value. Indeed, the usual definitions of the personal equation are not broad enough to cover or suggest the uncertainties of technical evidence.

And yet, if the truth is sought, technical evidence is to be handled just as all other human evidence is handled, and with the same promise of success. It comes to us either from interested or from disinterested parties, and the latter it has been the fashion to hold in great respect. It is, however, the fact that from them we can never get the truth, because we can never get the whole truth. One who has no interest in the matter one way or the other, either to know the truth in its entirety, or to state it with telling and, if possible, winning force, will not have the necessary impetus and stimulus either in the investigation and procuring of the facts, or in setting them forth in their fullness and in their most impressive attitude. They will not know it all, and they will not tell all they know, however honest may be their intentions. The disinterested party who is expected to tell both sides never so tells either side that there is not still much more that should be said. Keen interest is the greatest stimulus to truth telling, as sometimes also to truth concealing. The final result of disinterested evidence is to leave any question still unsettled, because all is never said on either side of it.

If the evidence of the disinterested man is insufficient, still more misleading and worse than worthless is it when one who is keenly interested upon one side will undertake the presentation of both. We are assuming all the while that every witness before us is honest and truthful, but we must not forget that every witness is also human, and it is surely asking too much of human nature to propose our acceptance of any living man as at once witness upon both sides and as counsel for both the prosecution and the defense.

It curiously happens that too much of the prepared and recorded evidence of mechanical achievements is of this *ex parte* character. While usually the statements are honestly presented, as honesty goes, both sides are not equally or adequately represented, and therefore the case is not fairly presented, and the record as it stands is worthless and misleading. The great work of the technical societies is not so much in procuring the valuable papers that are read before them as in securing the discussion of them, or the more or less adequate presentation of the other side. However admirable may be the papers, their authority can only be established by discussion, and the opportunity of preparing a proper presentation of the other side is of the greatest importance. The certainty of discussion to follow has inevitably a retroactive effect upon the preparation. Any man will be more careful and precise at every point if he knows that his work is to be all picked to pieces than if he knows that it will be swallowed whole.

In the case of electricity versus compressed air, or vice versa if it please anyone better, we have no interest in the one greater than in the other, but will gladly do what we can to secure adequate representation for each. It so happens that just at the present writing our attention is called to one of the *ex parte* reports of the character that we have been alluding to, and related to the above topics. It is the report of the supplanting of compressed air by electricity as a means of power transmission in a mine in Colorado. The report appeared simultaneously, or nearly so, in the columns of a most respected Electrical contemporary and neighbor, and in at least two other periodicals representing mining interests. Of course, neither publication is in any way responsible for the writer's statements or his deductions.

The opening sentence of the report speaks of the desirability of actual knowledge of the comparative performance of compressed air and of electricity under identical conditions, assuming, of course, that these conditions concurred in the case reported. The actual case, however, was that of an outrageously bad and dilapidated compressed air plant on the one hand, and of a respectable and up-to-date electric installation upon the other. The efficiency of the air was found to be 9 per cent. We need not speak of another detail. The idea of comparison was preposterous under the circumstances. It is not often that the most blindly zealous partisan is so carried away. Electricity surely is in no need of such narratives of its victories.

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Compressed Air in New York.

There are many indications that compressed air is to make quite a stir in New York in the near future. The American Air Power Company, controlling the Hardie motor for street-car service, with its unique record upon the One Hundred and Twenty-fifth street line, is in vigorous fighting condition. In about a month from this writing the Hardie compressed-air locomotive will be running a train upon the Sixth Avenue Elevated Railroad. Nearly allied to the above company is the General Compressed Air Company, interested in the numerous other applications of compressed air. And now, still later, is incorporated the Compressed Air Power Company, whose chief interest is in the Hoadley motor, which has been running successfully upon the Lenox Avenue line. The latter company has a large paid-up capital, and includes a number of most prominent and influential men in its directorate, including W. C. Whitney, ex-Secretary of the Navy. It is well known also that the Cramps, of Philadelphia, are interested in the Hoadley motor.

It is by no means inevitable that the adoption or rejection of compressed air for street-car service is to be determined

upon its merits, and in common justice the strongest organization of its friends and advocates is very necessary. It is in some sense unfortunate for compressed air that it does not require the tearing-up of the streets and the building of expensive conduits, as then it might claim the prospective contractors for that work as its friends instead of its enemies.

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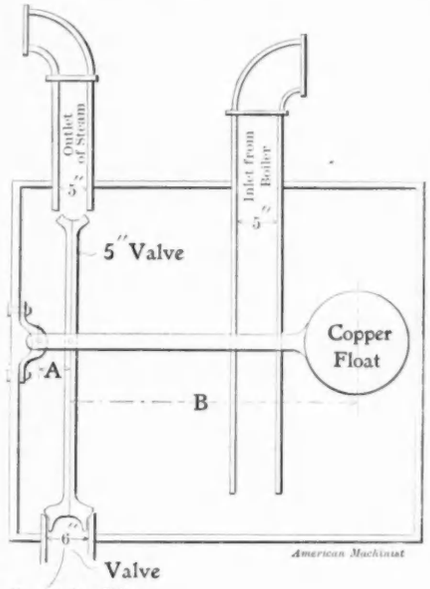
Questions and Answers.

Name and address of writer must accompany every question. Questions must pertain to our specialties and be of general interest. We cannot undertake to answer questions by mail.

(7) T. R. G., St. Louis, Mo., asks: Can you give me a formula by which I can get the weight of a cast-iron ball at a single operation? A.—The following is the simplest formula for the purpose that we know: $D^3 \times .1365$. The D, of course, stands for the diameter of the ball in inches. Say that we have a cast-iron ball 6 inches in diameter, what will be its weight? $6 \times 6 \times 6 \times .1365 = 29.484$ pounds.

(8) C. F. E., Chicago, sends the accompanying sketch and asks several questions: 1. Will a copper float raise the valve and stem, close the 5-inch valve at top and open the 6-inch valve at the bottom when steam is flowing out through the 5-inch valve at 80 pounds pressure and a rush of water comes from the boiler into the drum? A.—A copper float may be made to do this. 2. Does the valve at the top assist in raising the float, and would it be necessary to have a larger valve at the bottom? A.—The pressure upon the back or under side of the upper valve does assist to lift the lower valve, but how much is not easily



computable, especially as neither the full diameter of the valve head nor the vertical valve opening are given. It would not be necessary to have a larger valve at the bottom. 3. How can I figure the size of the float to use on the end of the lever, the leverage being 10 to 1? A.—The action of the apparatus would evidently be such that the float, lever and valves would never remain in any middle position, but whenever either valve was opened, the other would be immediately closed. Assuming, as per sketch, that the lower valve is closed, then the pressure on the valve will be $6^2 \times .7854 \times 80 = 2{,}261.95$ pounds, and with a leverage of 10 to 1 the weight to be lifted at the float will be, say, 226 pounds. As the float must operate to pull both upward and downward, we assume that it must float in the water about one-half immersed, with the weight of the lever, valves, valve stems, etc., but with no pressure on either valve. Then when entirely submerged, its lift would equal the weight of one-half of the water displaced by the sphere, and when entirely out of the water its downward pull would be the same. To save time, we assume that the float is a copper sphere 30 inches external diameter and ⅛ inch thick. The cubical contents of the sphere will be $30^3 \times .5236 = 14.137$ cubic inches $= 8.18$ cubic feet, and, assuming the water to be at least as hot as 212 degrees, the weight of water displaced by the entire ball will be $8.18 \times 60 = 491$ pounds. As the required lifting effort for opening the lower valve is 226 pounds, then $491 \div 2 = 245$ pounds; the lifting effect of the ball when entirely submerged, if balanced when half immersed, will only be slightly in excess of the requirements. The weight of the copper ball we compute to be $(30^3 - (29\frac{1}{4})^3) \times .5236 \times .3212$ (weight of cubic inch of copper) $= 112.6$ pounds. As this is less than one-quarter of the total displacement of the sphere, the ball, when floating free, will not sink half way in the water, but it will have the weight of the lever, valves, etc., added to its own weight, and it might be made of thicker copper, or other weights might be added to secure the proper immersion. As the pull for opening the lower valve would be greater than for the upper, it would be proper to have it float somewhat high. 4. In hardening with sperm oil, should the steel be dipped first in oil and then in water, or vice versa? I have taken annealed steel and dipped it in the sperm oil, but it would not get hard; and then, again, I have taken spring wire steel, annealed, and heated it to a low red, and it would break with a little pull, on account of being so hard. A.—The steel should be dipped in oil and left there. Only use water for the final cooling if your patience gives out. The smaller or thinner the piece hardened, the quicker it will be cooled and the harder it will be. Water cools heated steel quicker than oil will, and therefore makes it harder. Even water will not harden the face of an anvil very hard, and for that operation special means are provided for circulating the water to make it take away the heat more rapidly.

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Commercial Review.

NEW YORK, SATURDAY EVENING, JAN. 16TH.

MACHINISTS' SUPPLIES.

The situation, now that the year has been open for two weeks, while not yet greatly altered, is such as to afford ground for some encouragement. Out of some twenty local concerns with which we have communicated, about one-half report more or less improvement.

We are perhaps not yet free from the influences of inventory taking, but it is time to expect some manifestation of the attitude of consumers. People do not all take stock at the same time. In Pennsylvania and vicinity it is commonly done near the holidays, while in New England the tendency is to postpone it until about the first of February. The New York district is inclined to conform to the first-mentioned rule. A little more business than that of December would seem to be due at this time even with no change in actual conditions. This may account for some, if not all, of the better trade reported by those who find it, but the more satisfactory way is to assume that it means a real strengthening of undertone.

Many reports, to be sure, are of a most discouraging nature—that business is worse than in December or unchanged for months past; that credits are being shortened and more questions asked about customers; that the failure of factories to open as expected, and the collapse of Western banks, have cast a gloom upon the surroundings and been an obstacle to the return of confidence.

But as an off-set to the above, here are a few statements from some of the leading supply houses doing a large wholesale as well as retail business in mechanics' tools, etc.:

Montgomery & Co. say: "Although business is not yet anything to boast of, there is a better inquiry than there has been for six months past, and orders, too, are coming in—good orders, not orders for a twelfth of a dozen each. We look for a good, healthy trade after the middle of February or the first of March."

Patterson, Gottfried & Hunter report a greatly improved demand for machinists' supplies, especially fine tools, such as reamers, etc., while there is comparatively little call upon them for general hardware.

Peter A. Frasse & Co. also find that inquiries and orders are coming in better since the first of the year. Those buying are machine and electrical shops, variously; the bicycle repair shops not being in the market at present, nor the bicycle manufactories very noticeably.

The Arcade File Works, as learned from their general agency in this city, are now running full force, full time. Jobbers are buying more than they were some time ago, and orders are coming in better than they have done since last February.

Reynolds Brothers, Columbus, O., manufacturers of hand-cut files and rasps, write us that they are very busy at present, did more business last month than ever before, and that this month will exceed the last.

The Brightman Manufacturing Company, Millersburg, O., manufacturers of power-transmitting machinery, planer chucks, special mill machinery, etc., who have just located a plant in that city, write that they have some $40,000 worth of orders on hand and that the outlook is very bright.

POWER TRANSMITTING MACHINERY.

This is a line in which some improvement is manifest. Several of the leading concerns which supply it report fairly good orders, and, according to the ex-

perience of two which are perhaps as important as any, this better business has come within about a week past. Orders are, however, principally small ones for repair purposes. People who have repairing to do at the end of the year, in dull times like the present, sometimes prefer first to make up as good a financial report for the year as possible and to throw their purchasing over into January, which tendency may have something to do with present buying.

As a result of the legal complication among the wood pulley manufacturers, some of them are no longer in the field. The Gilbert pulley is still there, however, in opposition to the Dodge, and has advanced its prices. The Reeves is also there, having come to an understanding with the Dodge.

EXPORTS.

The centrifugal pump patented by Mr. Wm. O. Webber and manufactured by the Lawrence Machine Company, Lawrence, Mass., is reported as growing in favor at home and abroad, and within the last year the makers have shipped eleven to Japan, four to Mexico, three to the island of Trinidad, three to France, and quite a number to Canada.

A pump concern with an office on Liberty street, New York, is said to have done a business of over $30,000 with Spanish-American countries within the last four months. They are now building two large pieces for Buenos Ayres and four for Mexico, amounting altogether to about $18,700.

Orders have recently been placed for the following: Two car-loads of artesian well-driving machinery for Australia; $10,000 worth of water-tube boilers for shipment to Argentine Republic; a complete sawmill plant to go to Guatemala, and said to be larger than any other yet sent from here to that country.

A shipment about being made includes a 750 horse-power engine with trolley supplies, etc., for Buenos Ayres. The Ball

(Continued on page 37.)

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Business Specials.

Transient Advertisements 40 cents a line for each insertion under this head. About seven words make a line. Copy should be sent to reach us not later than Saturday morning for the ensuing week's issue.

Gear wheels, gear cutting. Grant; see page 16.

Brass turning done by H. D. Phelps, Ansonia, Ct.

Forming Lathes. Mer. Mach. Tool Co., Meriden, Ct.

Milling Machs. Kempsmith Co., Milwaukee, Wis.

Engine Castings ⅛ to 2 H. P. Finished boilers and engines. Grant Sipp, Paterson, N. J.

Selden Packing for stuffing box, with or without rubber core. Randolph Brandt, 38 Cortlandt st., N.Y

Correspondence solicited with firm wishing to develop gas engine business; photos. can be furn'd of 2 styles already built. Box 34, AMER. MACHINIST.

Duplex and special gear cutters, counterbores, cutter and surface grinders, vertical millers, hand punches and shears. R. M. Clough, New Haven, Ct.

The American Ball-Bearing Co., of Cleveland, have exceptionally good facilities for the manufacture of bicycle cups and cones; tempering, case hardening and grinding are a specialty with them.

Help Wanted.

Situation and Help Advertisements only inserted under this head. Rate 30 cents a line for each insertion. About seven words make a line. The Cash and Copy should be sent to reach us not later than Saturday morning for the ensuing week's issue. Answers addressed to our care will be forwarded.

TO SUBSCRIBERS

whose names appear on our **subscription** list, this paper will give two free insertions under this heading to those in want of positions. The advertisement to occupy a space of not more than five lines. Additional space or insertions must be paid for in advance at regular rates.

Pattern maker, A 1, seeks pos. Box 18, AM. MACH.

Wanted—Man used to running 20 foot boring mill; state experience and wages required. Apply Canadian General Electric Co., Peterboro, Ont.

Wanted—Pos. by a punch and die maker, large experience, expert tool maker, fair draughtsman. Address Box 35, care AMERICAN MACHINIST.

A strictly first-class draftsman and designer, pumps, boilers, hoisting and gen'l machinery, open for engagement. Box 41, AMERICAN MACHINIST.

Draftsman wants position; experienced in steam pump and general machinery; shop and drafting room experience. Box 39, AMERICAN MACHINIST.

Mechanical draftsman wants position; six years' varied shop experience and eight years as draftsman upon printing machy. Box 29, AMER. MACH.

Wanted—Position as foreman of mch. shop or tool room by man of extensive experience and ability; good manager of help. Best of reference. Address Box 44, AMERICAN MACHINIST.

Draftsman and machinist, 12 years' experience, desires a change; has been foreman in shop and is at present chief draftsman in a large concern. New Jersey preferred; good ref. Box 40, AM. MACH.

Wanted—Change of position by young man, 15 years' experience as machinist, tool maker, draftsman, foreman and superintendent; good refs. as to ability and integrity. Box 23, AMER. MACHINIST.

Supt. of good address and 15 years' exp. Gen'l and Transmission Mch'y, Mch. tools, Engines & Cranes, mem. A. S. M. E., would like position as traveling representative for first class Co. Box 43, AM. MCH.

First-class draftsman and tool maker desires situation; technical education as M. E.; 12 years' experience in shop and drafting room; successful foreman; prefer situation in drafting room. Address Box 20, AMERICAN MACHINIST.

Wanted—Pos. as foreman of tool room in bicycle factory; thoroughly up to date in every way; having had 15 years' experience in the bicycle line as workman, foreman and designer; Eastern experience chiefly. Box 37, AMERICAN MACHINIST.

Mechanical draftsman and practical machinist of 22 years' experience as workman, foreman and chief draftsman, conversant with best methods of doing work cheap and accurate, desires pos. in any of above capacities. Box 36, AMER. MACHINIST.

Wanted—By a thorough practical mechanic, tool maker and draftsman, pos. with an English bicycle, scientific instrument or specialty manuf'g concern where auto. and special mach'y is required; 16 yrs. exp.; A 1 ref.; correspd. desired. Box 38, AM. MACH.

Wanted—A superintendent for a drop forge plant employing 100 hands; must be capable of directing all departments and of turning out first-class work and on time; no estimating or office work required; state experience, age and salary expected. Address Box 27, AMERICAN MACHINIST.

A 1 expert and thorough mechanic on gas and gasoline engines, at present holding responsible position with large concern manuf'g gas engs., wishes to change; will accept pos. as manager or as general traveling salesman and expert with a firm that appreciates ability and inventive genius developing gas engines to highest efficiency, and electric lighting with same, a specialty. Box 1, AM MACH.

▲ ▲ ▲

Miscellaneous Wants.

Advertisements will be inserted under this head at 30 cents per line, each insertion. Copy should be sent to reach us not later than Saturday morning for the ensuing week's issue. Answers addressed to our care will be forwarded.

Cheap 2d h'd lathes & planers. S. M. York, Clev'd, O.

Calipers & Gauges. F. A. Welles, Milwaukee, Wis.

Best and cheapest Bolt Header, made by Baush & Harris Machine Tool Co., Springfield, Mass.

Light and fine mach'y to order; models and electrical work specialty. E. O. Chase, Newark, N. J.

For Sale—Second-hand drill presses, engine lathes & planers. Dietz, Schumacher & Boye, Cincinnati, O.

We make a specialty of Shartle's patent safety set collars. Prices low and samples free. Middletown Machine Co., Middletown, Ohio.

We offer an exceedingly fine lot of first-class second-hand machinery, lathes, planers, shapers, drills, millers, screw machines, etc. Call, or get list 17 B. The Garvin Mach. Co., 440 Canal st. N.Y.

Wanted—An Idea. Who can think of some simple thing to patent? Protect your ideas; they may bring you wealth. Write John Wedderburn & Co., Patent Attorneys, Washington, D. C., for their $1,800 prize offered to inventors.

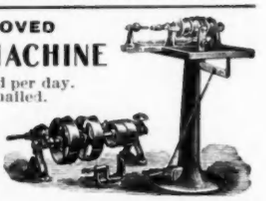
Wanted—A machinist who can invest $3,000 to $5,000 in a company doing a good machine and foundry business, located in N. Y. State, to take charge of machine shop; one who can manage men and turn out work cheaply. Box 42, AMERICAN MACHINIST.

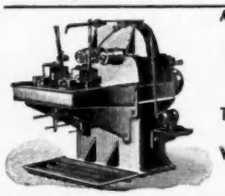
POSITION WANTED

By a Competent Engineer (member of A. S. M. E.) whose last 10 years' experience has been wholly in the lines of experimental and development work. Is now employed, and has been with present employers several years, but desires to make a change and prefers to undertake some radical departure from the ordinary rut, such as developing horseless wagons, etc. Address, appointing an interview if in the East,

Box 15, American Machinist.

NEW IMPROVED
TAPPING MACHINE
25,000 holes tapped per day.
Description mailed.
Machinery and Tools.
Brass Machine Screws.
HARVEY HUBBELL,
33-35 Organ St.,
Bridgeport, Conn.





Automatic Solid Die Bolt
THREADING MACHINES.
Two Styles. Four Sizes.
Send for Catalogue "A."
Webster & Perks Tool Co.
Cor. Spring and Monroe Sts.,
Springfield, Ohio.

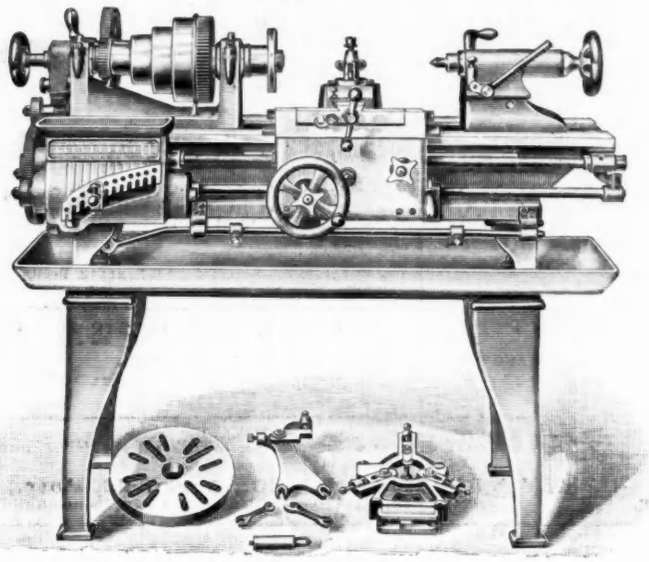
Columbia University
in the City of New York.

SCHOOL OF MINES,
SCHOOL OF CHEMISTRY,
SCHOOL OF ENGINEERING,
SCHOOL OF ARCHITECTURE,
SCHOOL OF PURE SCIENCE.

Four years' undergraduate courses and special facilities for graduate work in all departments. Circulars forwarded on application to the Secretary of the University.

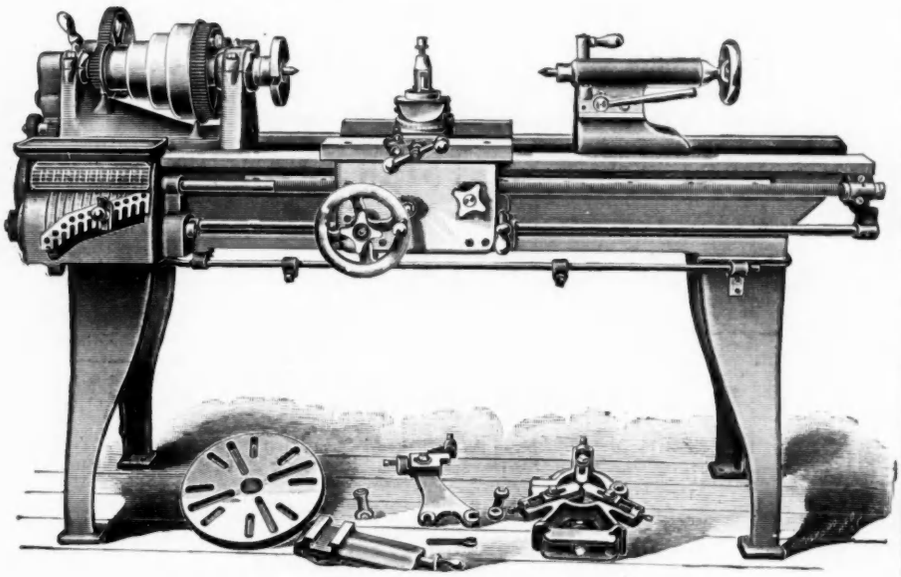
LATHES

FITCHBURG MACHINE WORKS
FITCHBURG, MASS., U. S. A.
METAL-WORKING MACHINERY.
CATALOG E.



12" Hendey-Norton Lathe

is fitted with drawing-in sleeve and American Watch Tool Co's standard chuck, used in making small taps, reamers, etc. Work finished first and cut from bar afterwards. No centering required. See carriage reverse lever by right-hand side of apron; no reaching for countershaft shipper required.



14" x 6' Hendey-Norton Lathe.

These lathes are modern, high-grade, practical tools, and are specially adapted for tool-room work. They have the Norton Attachment for screw cutting, giving 36 different threads and 36 different feeds with only two changes of gear and movement of lever in gear-box from one notch to the other. Note the automatic stop under apron. It will automatically stop carriage at any desired point in either direction; invaluable for internal or duplicate work. SEND FOR CATALOGUE.

The Hendey Machine Company,
Torrington, Conn.

Agents for the Pacific Coast, Pacific Tool & Supply Co., San Francisco, Cal.

European Agents: Chas. Churchill & Co., London and Birmingham, Eng.
Schuchardt & Schütte, Berlin and Vienna.
Eugen Soller, Basel, Switzerland.

(Continued from page 36.)

Engine Co., Erie, Pa., will soon ship a 400 horse-power vertical cross-compound engine intended to run by direct connection a 225 kilowatt Siemens-Halske generator, to the Nicopal Mariopol Mining & Metallurgical Co., Mariopol, Russia. An inquiry has come from Chile for three powerful flat bottomed tug boats.

Quotations.

NEW YORK, Monday, January 18th.

Iron—American pig, tidewater delivery:

No. 1 foundry, Northern	$12 00 @ $13 00
No. 2 foundry, Northern	11 75 @ 12 00
No. 2 plain, Northern	11 25 @ 11 50
Gray Forge	10 75 @ 11 50
No. 1 foundry, Southern	11 50 @ 12 00
No. 2 foundry, Southern	11 00 @ 11 25
No. 3 foundry, Southern	10 50 @ 11 00
No. 1 soft, Southern	11 00 @ 11 50
No. 2 soft, Southern	10 50 @ 11 00
Foundry forge, or No. 4 Southern	10 25 @ 11 00

Bar Iron—Base—Mill price, in carloads, on dock; common, 1.10 @ 1.15c.; refined, 1.20 @ 1.50c. Store prices: common, 1.40 @ 1.50c.; refined, 1.50 @ 1.80c.

Tool Steel—Ordinary sizes, standard quality, 6 @ 7c., with some brands perhaps a little less; extra grades, 11 @ 12c.; special grades, 16c and upward.

Machinery Steel—Ordinary brands, from store, 1.60 @ 1.65c.

Cold Rolled Steel Shafting—Base size in carloads, about 2½c.; 2¾c. for smaller quantities from store. The base has been changed from 1-16-3 in. to 1-3 in.

Copper—Carload lots, Lake Superior ingot, 11.80 @ 12.00c; electrolytic, 11⅜ @ 11½c.; casting copper, 11½ @ 11⅝c.

Pig Tin—For 5 and 10 ton lots, 13.45 @ 13.50c., f. o. b.

Pig Lead—In carload lots, 3.02½ @ 3.07½c., f. o. b.

Spelter—In carload lots, New York delivery, 3.90 @ 4.00c., f. o. b. and upward.

Antimony—Cookson's, 7⅛ @ 7½c.; Hallett's, 6⅝ @ 6¾c.

Lard Oil—Prime city, present make, commercial quality, in wholesale lots, 40 @ 42c.

▲ ▲ ▲

Manufactures.

Herman Florian, Fostoria, O., is erecting a boiler shop.

Louise Yarn Mills at Charlotte, N. C., will be enlarged.

L. W. Brown, Woodstock, Va., intends to install an electric light plant.

At Elizabeth, N. J., the Venetian Iron Company has been incorporated.

The Warren City Boiler Works, Warren, O., intend to erect a new plant.

Herman Noss & Sons, York, Pa., are having a new boiler house erected.

It is expected that the Johnson Company, Lorain, O., will erect blast furnaces.

The Ford morocco factory at Wilmington, Del., is to have a large addition built.

The Capron Knitting Company, Utica, N. Y., will soon enlarge its plant considerably.

The Wilson Carbide Works Company has been incorporated at St. Catherines, Ont.

The Glenn Driller Company, of New Brighton, Pa., is shortly to erect a new factory.

William Metcalf, of Pittsburg, Pa., is completing arrangements to erect a new steel mill.

The Derwent Foundry Company's plant at New Castle, Pa., was destroyed by fire recently.

Laidlaw-Dunn-Gordon Company, Cincinnati, O., will build a new foundry in the near future.

Sands Bros., Moundsville, W. Va., intend to erect a bleaching mill, and will place new machinery.

Matthais, Ingram & Co., Baltimore, Md., manufacturers of tin plate, are erecting new buildings.

The Laughlin Nail Company, Martin's Ferry, O., will shortly commence the erection of a new mill.

The paint factory of Schroeder, Smith & Schroeder, of Lancaster, Pa., was recently destroyed by fire.

The Piscataquis Woolen Company, of Guilford, Me., will shortly add new machinery to its equipment.

The machine shop of H. P. Redman, Market street, Newark, N. J., was destroyed by fire recently.

At Tacoma, Wash., new machine shops will be

erected by J. O. Bradney. New machinery will be installed.

The flouring mill of Waly, at Ostrander, Del., including machinery, was recently completely destroyed.

The tannery of P. McGraw & Co., Allegheny, Pa., recently destroyed by fire, will be rebuilt on the same site.

The Pittsburg Tin Plate Company will soon commence to erect an addition to its mill at Kensington, Pa.

The wood working plant of Wm. Nice, Jr., Marriott street, Philadelphia, Pa., is to have an addition erected.

The Bedford Portland Cement Company, of Cleveland, O., contemplate the erection of a mill at Bedford, Ind.

The Acme Sucker Rod Company has purchased the old Toledo (O.) Bolt and Nut Works, and will erect a factory on it.

The Morley Button Machine Company, of Portsmouth, N. H., is considering plans for the erection of another large factory.

The Anthracite Wagon Company, at Cameron and Market streets, Harrisburg, Pa., intends to erect an addition to its plant.

The Bessemer Steel Works at Pueblo, Colo., is preparing to put in a structural department for the manufacture of bridge and heavy iron.

The machinery of the plant of the Maine & New Brunswick Red Granite Company, Calais, Me., was considerably damaged in the recent fire.

At Kansas City, Mo., the Beulah Manufacturing Company has been incorporated. Directors: P. K. Connaway, H. H. Leonard and Baird Pallette.

Knouse & Collum Boiler Works, Allentown, Pa., will move their plant from South Third to Walnut street. The plant will be re-erected and enlarged.

The Walker Manufacturing Company, Cleveland, O., will ship an electrical street car equipment to Alexandria, Egypt, soon. The capacity of the plant will be 10 large motor cars and 10 trailers.

The J. Stevens Arms and Tool Company have dissolved connection with Wiebusch & Hilger, Limited, as manufacturers and their agents, and will now have their office at 79 Chambers street, N. Y. City.

The Challenge Wood Pulp Grinder Company, of Rochester, N. Y., has been incorporated. The company will engage in the manufacture and sale of pulp grinders and other appliances used in the manufacture of paper. The directors are Bernard Eilers, Wm. A. Murphy, etc., of Rochester.

The Davis & Egan Machine Tool Company, of Cincinnati, O., has just secured the premises on Sixth street, extending from Eggleston avenue to Lock street, which is just across the street from their present factory, and will immediately commence the erection of a warehouse at this location.

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New Catalogs.

There are three sizes of Standard Catalogs, first authorized by the Master Car Builders' Association, 9" x 12", 6" x 9" and 3½" x 6". We recommend the 6" x 9" size for machinery catalogs. When they must be larger or smaller, one of the other standard sizes should be adopted if possible.

The P. H. & F. M. Roots Co., Connersville, Ind., send us catalog devoted to the illustration and description of gas exhausters. It is 6¾ x 9 inches.

We have received from the Betts Machine Company, Wilmington, Del., copy of their catalog containing illustrations and descriptions of extension boring and turning mills. The catalog is standard size 6 x 9 inches.

We have received from the American Steam Gage Company, Boston, Mass., a catalog which contains illustrations and descriptions of a variety of gages, also indicators, planimeters, etc. It is standard size, 6 x 9 inches.

We have received from Jos. Dixon Crucible Co., Jersey City, N. J., two catalogs, one containing description of graphite paint, and the other testimonials from those who have used it. The catalogs are standard size, 6 x 9 inches.

Thos. Carlin's Sons, Allegheny, Pa., send us catalog "J," containing illustrations and descriptions of bar shears, rock and ore crushers, traveling cranes, derricks and other machinery used by contractors. The catalog is 6 x 9¼ inches.

The Pratt & Whitney Co. HARTFORD, CONN., U.S.A.

...MAKERS OF...

Fine Machine Tools.

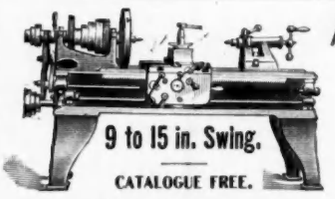
Complete Plants furnished for Bicycle, Typewriter, Gun and Sewing Machine Makers. Gauges and Small Tools for all Machine Work. Drop Hammers and Trimming Presses. Forging and Trimming Dies for all classes of work.

England—BUCK & HICKMAN, 280 Whitechapel Road, London, E.
France—FENWICK FRERES & Co., 21 Rue Martel, Paris.
Germany and Austria—SCHUCHARDT & SCHUTTE, Berlin and Vienna.
Chicago—42 and 44 South Clinton St. *Boston*—281 Franklin St. *New York*—123 Liberty St.

SUPERIOR QUALITY OF TAPPER TAPS.
ADJUSTABLE PLATE AND MACHINE DIES.
"Lightning" and "Green River" Screw Plates, Tap Wrenches, Reamers, Bolt Cutters, Drilling Machines, etc.

SEND FOR CATALOGUE. WILEY & RUSSELL MFG. CO., Greenfield, Mass., U. S. A.
Agents in London, SELIG, SONNENTHAL & CO., 85 Queen Victoria Street.

WIRE
ITS MANUFACTURE AND USE.
BY J. BUCKNALL SMITH.
8VO, CLOTH, $3.00.
JOHN WILEY & SONS,
53 East Tenth Street, NEW YORK.



CATALOGUE FREE.

ARE YOU LOOKING for a lathe? We are building them in various sizes from 9 in. to 15 in. swing, in various lengths, both engine and speed lathes. Our designs are the **latest**, while the **workmanship, material** and **finish** are of the **highest** order. Our catalogue will tell you all about them, as well as of our planers, shapers and other tools.
SEBASTIAN LATHE COMPANY,
117 & 119 Culvert St., Cincinnati, Ohio, U. S. A.

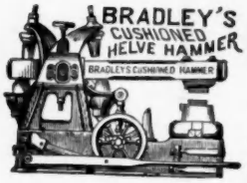
DYER & DRISCOLL,
PATENT SOLICITORS, 36 WALL ST., N.Y.
Have done all my patent soliciting work, both for this and foreign countries, continously for the past fourteen years.
Thomas A. Edison

STAR LATHES
★ ★ ★
Foot Power Screw Cutting, Automatic Cross Feed, 9 and 12" Swing.
Send for Catalog B.
Seneca Falls Mfg. Co.
687 Water St., Seneca Falls, N.Y.

WE CLAIM THE FOLLOWING MERITS FOR JENKINS BROS.' VALVES.
1. Manufacturered of the best Steam Metal.
2. No regrinding, therefore not constantly wearing out the Seat of the Valves.
3. Contain JENKINS DISC, which is suitable for all Pressures of Steam, Oil and Acids.
4. The Easiest Repaired, and all parts Interchangeable.
5. Every Valve Tested before leaving the factory.
6. ALL GENUINE stamped with Trade Mark.
JENKINS BROTHERS, New York, Philadelphia, Chicago, Boston.

EMERY WHEELS
NORTON Emery Wheel Co.
Worcester, Mass.

NEW COMPLETE ILLUSTRATED CATALOGUE FREE.



BRADLEY HAMMERS
THE BEST POWER HAMMERS ON EARTH.
22 sizes in Helve, Upright and Strap Styles.
Send for Printed Matter.
The Bradley Company
Syracuse, N. Y.

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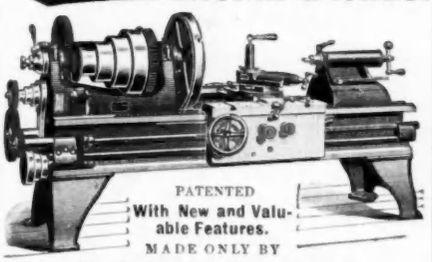

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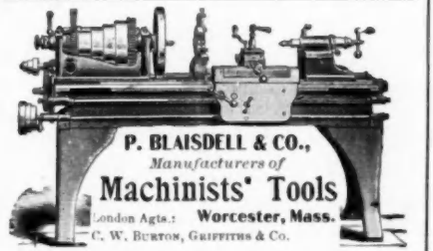

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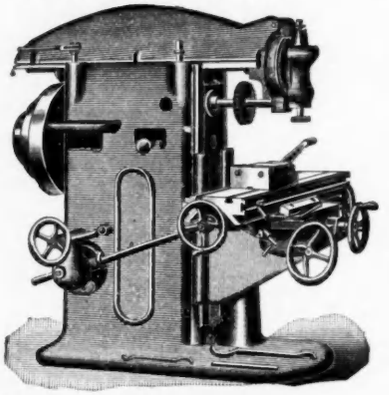

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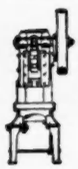

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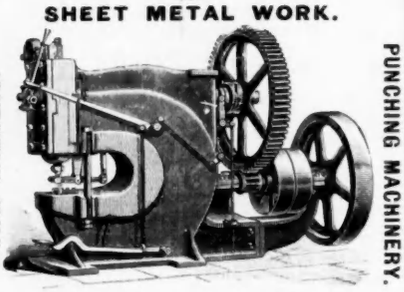

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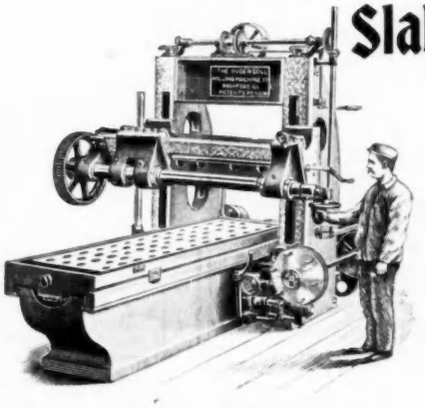

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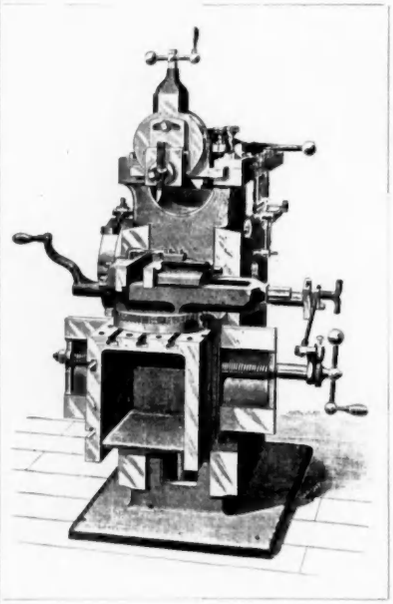

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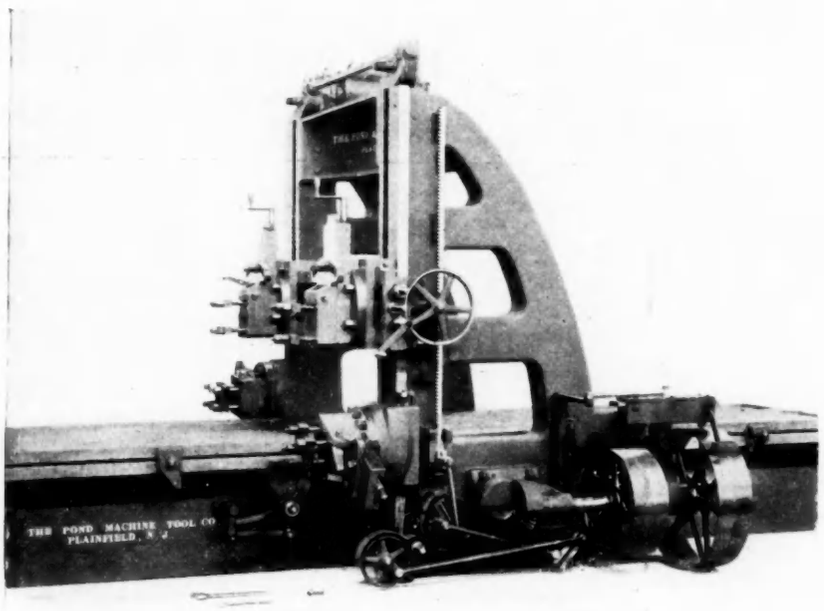

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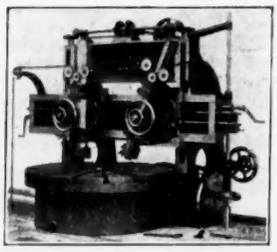

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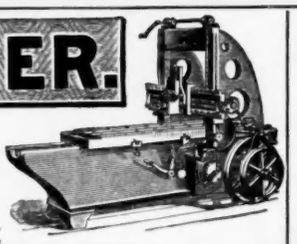

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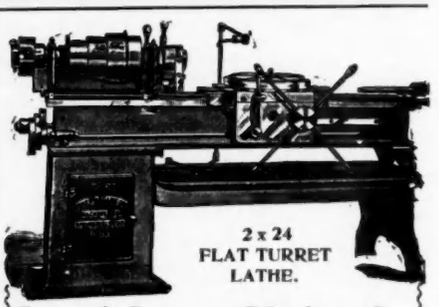

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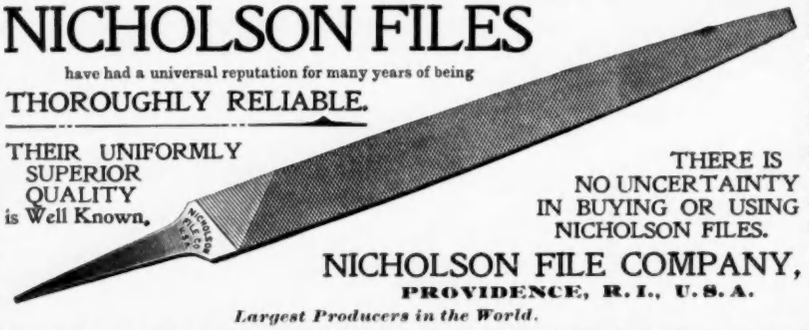

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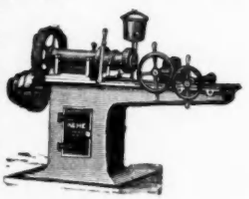

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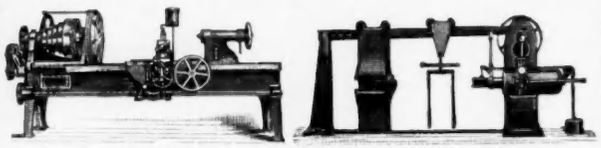

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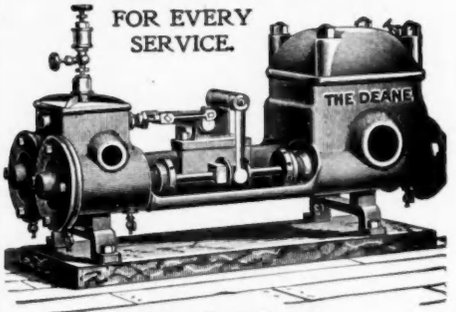

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